Pine Lake
Aquatic Vegetation Management Plan

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Prepared for:
Laporte Area Lake Association
328 Oak Drive
Laporte, IN 46350

Prepared by:
Nathan W. Long
Aquatic Control, Inc.
PO Box 100
Seymour, Indiana 47274

Executive Summary

Aquatic Control was contracted by the Laporte Area Lake Association to complete aquatic vegetation sampling in order to develop a lakewide, long-term integrated aquatic vegetation management plan. Funding for development of this plan was obtained from the Laporte Area Lake Association and the Indiana Department of Natural Resources-Division of Soil Conservation as part of the Lake and River Enhancement fund (LARE). This plan was created in order to address concerns over nuisance aquatic vegetation and as a prerequisite to eligibility for LARE program funding to control exotic or nuisance species.

Pine Lake has a very abundant and diverse native plant community. This plant community is beneficial for filtering nutrients, providing fish and invertebrate cover, and reducing the effects of wave action. Aquatic vegetation is an important component of lakes in Indiana; however, as a result of many factors this vegetation can develop to a nuisance level. Nuisance aquatic vegetation, as used in this paper, describes plant growth that negatively impacts the present uses of the lake including fishing, boating, swimming, aesthetic, and lakefront property values. At the time of the survey a wide variety of native species were creating nuisance conditions in and around dock areas. The exotic species Eurasian watermilfoil (*Myriophyllum spicatum*) was observed at only one site (this species was observed throughout the lake in earlier pre-treatment surveys). This exotic species can quickly spread and create nuisance conditions. It is important that this species be controlled in order to prevent its spread. The negative impact of this species on native aquatic vegetation, fish populations, water quality, and other factors is well documented and will be discussed in further detail. The primary recommendations for plant control within Pine Lake includes the use of contact herbicides in order to reduce nuisance conditions in high use areas. Along with this treatment a plant survey should be conducted in May of 2005 in order to locate any Eurasian watermilfoil beds. Eurasian watermilfoil should be treated with a systemic herbicide in order to keep this species from spreading throughout the lake and displacing native vegetation.

Acknowledgements

Funding for the vegetation sampling and preparation of an aquatic vegetation management plan was provided by the Indiana Department of Natural Resources – Division of Soil Conservation and the Laporte Area Lake Association. Aquatic Control Inc completed the field work, data processing, and map generation. Identification and verification of some plant specimens was provided by Dr. Robin Scribailo of Purdue University North Central. Special thanks are due to Sue Heikes of the Laporte Area Lake Association for help in initiating and completing this project. Special thanks are given to the public for their valuable input and suggestions at the November meeting. Special thanks are given to Mr. Jed Pearson with the Indiana Department of Natural Resources – Division of Fish and Wildlife for his assistance with the plant sampling database. Special thanks are due Mr. Cecil Rich and Mr. Bob Robertson, biologists for the Indiana Department of Natural Resources, for their review of this report. Author of this report is Nathan Long of Aquatic Control Inc. The author would like to acknowledge the valuable input from David Isaacs, Brian Isaacs, Joey Leach, and Barbie Huber of Aquatic Control for their field assistance, map generation, review, and editing of this report.

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Introduction

Aquatic Control was contracted by the Laporte Area Lake Association (LALA) to complete aquatic vegetation sampling in order to develop a lakewide, long-term integrated aquatic vegetation management plan. Funding for development of this plan was obtained from the Indiana Department of Natural Resources-Division of Soil Conservation as part of the Lake and River Enhancement fund (LARE). This plan was created to address the management of nuisance and exotic vegetation and as a prerequisite to eligibility for LARE program funding to control exotic or nuisance species.

Pine Lake is home to an abundant and diverse native plant community. However, some of these species create nuisance conditions in and around high-use areas. In order to address this problem, the Laporte Area Lake Association has put forth funding for creation of this plan. The Association has set three aquatic vegetation management goals:

1. Prevent further water use impairment by nuisance aquatic plants while minimizing the negative impacts on fish and wildlife resources.
2. Maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality, and is resistant to minor habitat disturbances and invasive species.
3. Promote the use of environmentally sound aquatic plant management techniques with control efforts focused on invasive species.

In order to achieve the first goal, regular contact herbicide treatments have been completed in some nuisance areas. The exotic species Eurasian watermilfoil and curlyleaf pondweed (*Potamogeton crispus*) are also present in Pine Lake. These species have created nuisance conditions prior to past herbicide applications. However, curlyleaf pondweed was not present in the 2004 sampling (this species typically reaches maximum abundance in late spring or early summer), and Eurasian watermilfoil was only present at one site. In order to insure that the diverse native plant population continues to exist in Pine Lake, it will be important to keep these exotic species from spreading and creating nuisance conditions.

Watershed and Water Body Characteristics

Pine Lake is a 564 acre natural lake located on the northwest side of Laporte, Indiana. Pine Lake is connected to Stone Lake (140 acres) by what used to be a navigable channel under Waverly Road. At the time of the survey, Pine Lake was experiencing low water levels and the channel with Stone Lake was not navigable. It appears Pine Lake has a very small watershed and the majority of the water comes from ground water. The low water levels may be caused by the below normal water table being experienced near Lake Michigan. There is very little data available on this topic and steps need to be taken to further understand this relationship. This type of study is beyond the scope of this report.

During normal water level conditions, Pine Lake has a maximum depth of 50 feet and an average depth of 8 feet (Figure 1). Pine Lake is located in a highly developed area, but the waters are very clear. District fisheries biologist Bob Robertson found that water clarity averaged nearly 13 feet over the four fish surveys which were conducted from 1976 to 2000 (Robertson, 2000). Secchi disk readings were 7 feet at the time of the plant survey. Some basic water quality measurements were taken. Alkalinity was 68.4 mg/l and pH was measured at 8.2. Ortho-phosphate was measured at 0.1 mg/l and nitrate was 0.1 mg/l.

Figure 1. Bathymetric Map of Pine Lake (Bright Spot Maps, 1996)

Not a lot of time and effort has been placed on studying the watershed or water quality at Pine Lake. A study focusing on watershed and water quality improvements should be considered in the near future, but this is beyond the scope of an aquatic vegetation management plan. Watershed improvements will help insure good water quality for future generations, but watershed improvements and reduction in phosphorus levels will not control nuisance vegetation. As watersheds are improved water clarity will increase. This in turn will increase light penetration and allow for vegetation to grow in deeper water. Submersed vegetation obtains the majority of necessary nutrients from the sediment and sediment in this area contains sufficient nutrients for plant growth. A study was recently completed by the Department of Fisheries and Aquatic Sciences at the University of Florida. The study compared the amount of available nutrients to plant growth. They sampled aquatic plants in 319 lakes between 1983 and 1999 and found no significant correlation between nutrients in lake water and the abundance of rooted aquatic plants (Bachman et. al., 2002).

Fisheries

Fish surveys have been completed on Pine Lake in 1976, 1983, 1989, and 2000. The most recent survey was completed on June 19, 2000 by the Indiana Department of Natural Resources. The survey included 10 overnight gill net lifts, 5 overnight trap nets, and 1.25 hours of nighttime DC-electrofishing. A total of 610 fish, representing, 19 species were collected. Bluegill (*Lepomis macrochirus*) ranked first in abundance by number at 42% of the catch, followed by largemouth bass (*Micropterus salmoides*) (22%), yellow perch (*Perca flavescens*) (18%), redear sunfish (*Lepomis microlophus*)(7%), warmouth (*Lepomis gulosus*) (4%), and smallmouth bass (*Micropterus dolomieui*) (2%). The remaining species, yellow bullhead (*Ictalurus natalis*), brown bullhead (*Ictalurus nebulosus*), bowfin (*Amia calva*), brook silverside (*Labidesthes sicculus*), lake chubsucker (*Erimyzon sucetta*), grass pickerel (*Esox americanus*), black crappie (*Pomoxis nigromaculatus*), blacknose dace (*Rhinichthys atratulus*), walleye (*Stizostedion vitreum*), banded killfish (*Fundulus diaphanous*), common carp (*Cyprinus carpio*), golden shiner (*Notemigonus crysoleucas*), and Johnny darter (*Etheostoma nigrum*), all make up less than 1% of the catch (Table 1).

Table 1. Species collected from Pine and Stone Lakes, June 19-June 29, 2000 (Robertson, 2000).

Species Collected	Number	Percent
Bluegill	254	41.6
Largemouth Bass	133	21.8
Yellow Perch	109	17.9
Redear Sunfish	40	6.6
Warmouth	23	3.8
Smallmouth Bass	10	1.6
Yellow Bullhead	6	1.0
Brown Bullhead	6	1.0
Bowfin	6	1.0
Brook Silverside	5	0.8
Lake Chubsucker	4	0.7
Grass Pickerel	4	0.7
Black Crappie	3	0.5
Blacknose Dace	2	0.3
Walleye	1	0.2
Banded Killfish	1	0.2
Carp	1	0.2
Golden Shiner	1	0.2
Johnny Darter	1	0.2

The bluegill fishery appeared to be unchanged compared to past surveys. However, largemough bass showed an increase in the abundance of quality fish. Yellow perch size and abundance did not show significant difference compared to previous surveys, however redear sunfish were larger on average than previous surveys (Robertson, 2000).

Aquatic vegetation is important to fisheries management. A fishery can be maintained without aquatic vegetation, but overall productivity will likely be lower. Aquatic vegetation provides cover for fish and aquatic insects, spawning substrate for some species like yellow perch, and increases the overall productivity of a lake. However, too much aquatic vegetation can be harmful to the balance of a fish population.

Present Water Body Uses

Pine Lake is a popular fishing, swimming, and water skiing lake. Several fee boat ramps are located around the lake. A public boat launch is located in Stone Lake. This ramp can be accessed through a channel on the south side of Pine Lake. A public beach is located in the southeast corner of Pine Lake. The shoreline of Pine Lake is highly developed. The only undeveloped areas are located in the northwest and southeast corners of the lake (Figure 2). Residents on Pine Lake have expressed concern over dense vegetation limiting dock access and clogging swimming areas in front of their homes. Many resident are concerned over the dangers posed by this vegetation to swimmers (Public Meeting, Nov. 22, 2004). There is high speed boating allowed in open areas of Pine Lake.

Figure 2. Lake Usage Map (not to scale see appendix)

Aquatic Plant Community

Vegetation sampling was completed prior to development of this plan. Past sampling has been completed by the IDNR prior to conducting fish surveys. The most recent IDNR survey was completed in 2000. Eighteen aquatic plant species were documented. Eurasian watermilfoil and curlyleaf pondweed were the only exotic species. Biologists noted that a single species rarely dominated a plant bed hence percent coverage of an individual species was difficult to determine (Robertson, 2000).

Tier I and Tier II sampling was completed on Pine Lake on August 27, 2004. Ideally, two Tier II surveys should be completed in a season in order to document changes in plant community characteristics that occur over the course of the spring through late summer seasons, but due to time limitations a single survey was completed in 2004.

Tier I survey

The Tier I survey was developed to serve as a qualitative surveying mechanism for aquatic plants. The Tier 1 survey is based upon the procedure manual developed by Shuler & Hoffmann, 2002. This survey will serve to meet the following objectives:

1. to provide a distribution map of the aquatic plant species within a waterbody
2. to document gross changes in the extent of a particular plant bed or the relative abundance of a species within a waterbody (IDNR, 2004)

The Tier 1 survey revealed six distinct plant beds within Pine Lake totaling 466.09 acres (Table 2 & Figure 3). Seventeen different species were observed growing to a maximum depth of 20 feet. Eurasian watermilfoil was the only exotic species sampled.

Table 2. Tier I Survey Results.

Plant Bed I.D.	**1**	**2**	**3**	**4**	**5**	**6**
Plant Bed Size (acres)	**230.00**	**68.49**	**73.52**	**18.86**	**51.00**	**12.11**
	Rating*	**Rating***	**Rating***	**Rating***	**Rating***	**Rating***
Largeleaf pondweed	3	2	4	2	3	2
Eel grass	3	3	3	3	2	2
Fern pondweed	3	3	2	3	3	1
Coontail	2	2	1	1	-	-
Sago pondweed	1	-	-	2	1	2
American elodea	2	2	1	1	1	-
Northern watermilfoil	1	2	1	1	1	1
Eurasian watermilfoil	1	2	1	1	1	1
Bur-Marigold	1	-	-	-	-	-
Flatstem pondweed	1	1	-	-	-	-
Water stargrass	1	1	1	-	-	-
Slender naiad	1	1	1	1	1	-
Chara	1	1	1	1	1	1
Spatterdock	1	1	1	1	-	3
White water lily	-	-	1	1	-	1
Variable pondweed	-	-	-	2	1	-
Broadleaf watermilfoil	-	-	-	-	-	3

*Rating is based on a score 1-4 with 1 being least abundant and 4 being most abundant.

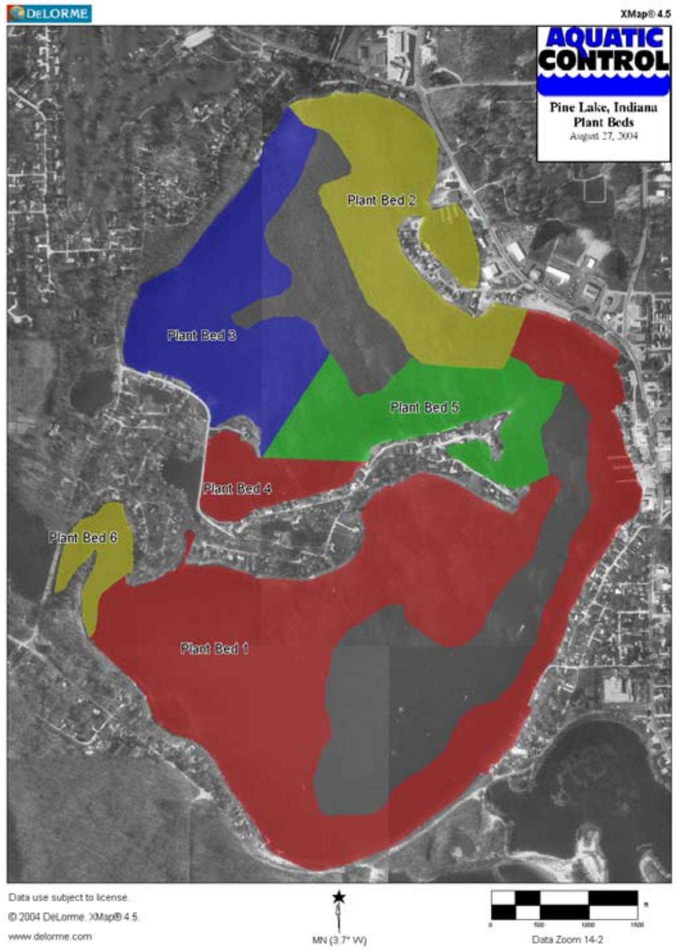

Figure 3. Tier I Plant Beds, Pine Lake, August 20, 2004 (not to scale see appendix)

Plant bed 1 included almost the entire littoral area of the southern basin (Figure 3). This plant bed was determined to be 230 acres. The substrate of plant bed 1 was sand. A total of 14 species were observed within the plant bed. Largeleaf pondweed (*Potamogeton amplifolius*), fern pondweed (*Potamogeton robbinsii*), and eel grass (*Valisneria americana*) were the dominant plant species (21-60% abundance rating). Coontail (*Ceratophyllum demersum*) and American elodea (*Elodea canidensis*) were found at 2-20% abundance. Northern watermilfoil (*Myriophyllum sibircum*), Eurasian watermilfoil, bur marigold (*Bidens beckii*), flatstem pondweed (*Potamogeton zosteriformis*), water stargrass (*Zosterella dubia*), slender naiad (*Najas flexilis*), chara (*Chara spp.*), sago pondweed (*Potamogeton pectinatus*), and spatterdock (*Nuphar spp.*) were present at less than 2% abundance.

Plant bed 2 was located just north of plant bed 1 in the northeast corner of the north basin (Figure 3). This plant bed was determined to be 68.49 acres. The substrate of plant bed 2 was sand. A total of 12 species were observed within the plant bed. Eel grass and fern pondweed were the dominant species (21-60%). Largeleaf pondweed, American elodea, northern watermilfoil, Eurasian watermilfoil, and coontail were present at 2-20%

abundance. Flatstem pondweed, water stargrass, slender naiad, chara, and spatterdock were also observed (<2%).

Plant bed 3 was located on the western edge of the north basin (Figure 3). Plant bed 3 was determined to be 73.52 acres. The substrate of plant bed 3 was sand. A total of 12 species were observed within the plant bed. Largeleaf pondweed was the dominant species in this area (>60%). Eel grass was present at 21-60% abundance. Fern pondweed was third in abundance at 2-20%. American elodea, northern watermilfoil, Eurasian watermilfoil, water stargrass, coontail, slender naiad, chara, white water lily (*Nymphaea tuberosa*), and spatterdock were also observed (<2%).

Plant bed 4 was located in the southwest corner of the north basin (Figure 3). This plant bed was determined to be 18.86 acres. The substrate of plant bed 4 was sand. A total of 13 species were observed within the plant bed. Eel grass and fern pondweed were the most abundant species (21-60%). Largeleaf pondweed, variable pondweed (*Potamogeton gramineus*), and sago pondweed were present at 2-20% abundance. American elodea, northern watermilfoil, Eurasian watermilfoil, coontail, slender naiad, chara, spatterdock, and white water lily were also observed (<2%).

Plant bed 5 was located east of plant bed 4 (Figure 3). This plant bed was determined to 51.0 acres. The substrate of plant bed 5 was sand. A total of 10 species were observed within the plant bed. Largeleaf pondweed and fern pondweed were the most abundant species (21-60%). Eel grass was present at 2-20% abundance. American elodea, northern watermilfoil, Eurasian watermilfoil, slender naiad, chara, variable pondweed, and sago pondweed were also observed in this area (<2%).

Plant bed 6 was located in the far western corner of the south basin (Figure 3). This plant bed was determined to 12.11 acres. The substrate of plant bed 6 was silt/clay. A total of 11 species were observed within the plant bed. Broadleaf watermilfoil (*Myriophyllum heterophyllum*) and spatterdock were the most abundant species (21-60%). Eel grass, largeleaf pondweed, and sago pondweed were present at 2-20% abundance. American elodea, northern watermilfoil, Chara, slender naiad, fern pondweed, northern watermilfoil, Eurasian watermilfoil, and white water lily were also observed in this area (<2%).

Tier II Survey

Creation of the aquatic vegetation management plan also requires sampling to quantify the occurrence, distribution, and abundance of aquatic vegetation. This type of survey will be referred to as the Tier II survey. This protocol is currently being used by the IDNR Division of Fish and Wildlife to provide a quantitative sampling mechanism for aquatic plant surveying. This protocol supplements the Tier I Reconnaissance Protocol for plant bed mapping. Together the protocols should serve to meet the following objectives:

1. to document the distribution and abundance of submersed and floating-leaved aquatic vegetation

2. to compare present distribution and abundance with past distribution and abundance within select areas (IDNR, 2004).

All of the data which was collected through the use of this protocol was recorded on standardized data sheets (Appendix C). The data collected was compared to data collected by District fisheries biologist Jed Pearson, which is presented in his 2004 paper "A Sampling Method to Assess Occurrence, Abundance, and Distribution of Submersed Aquatic Plants in Indiana Lakes". In this paper, Pearson used 21 northern Indiana lakes to calculate various aquatic plant abundance and diversity metrics. We used the same sampling procedure outlined in Pearson's paper to calculate these same metrics for Pine Lake. The data collected will also be valuable for future comparison, which will document changes in the plant community following proposed management activities.

Sample sites were randomly selected throughout the littoral zone (the number of sample sites is pre-determined and is based on lake size). Once a site was reached the boat was slowed to a stop and the coordinates were recorded on a hand-held GPS unit and later downloaded into a mapping program. A depth measurement was taken by dropping a two-headed standard sampling rake that was attached to a rope marked off in 1-foot increments (Figure 4). An additional ten feet of rope was released and the boat was reversed at minimum operating speed for a distance of ten feet. Once the rake is retrieved the overall plant abundance on the rake is scored from 1-5 and then individual species are placed back on the rake and scored separately (the rake is marked off in 5 equal section on the tines, a score of 1 is lowest abundance and 5 is highest).

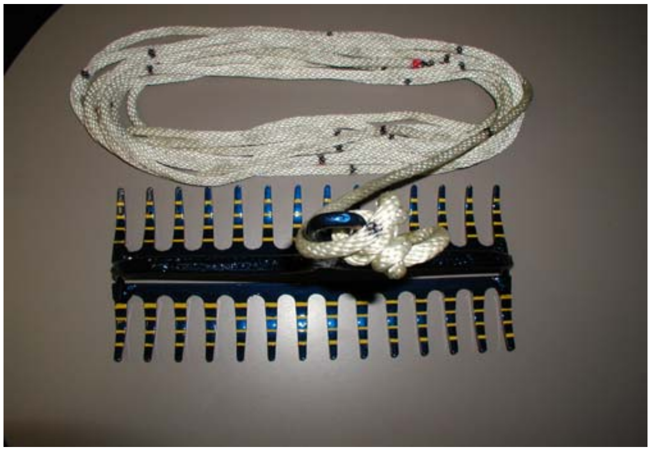
Figure 4. Sampling Rake

Tier II sampling took place on August 27, 2004 immediately following the Tier I sampling. A secchi disk reading was taken prior to sampling and was found to be 7 feet. Plants were present to a maximum depth of 20 feet. Ninety-three sites were randomly selected for sampling (Figure 5). The mean depth from which samples were taken was 6.28 feet. Aquatic vegetation was present at 96% of sample sites. The mean rake density score for Pine Lake was 4.05. Species richness (average number of species per site) was 3.91 for all species and 3.90 for natives only. Site species diversity index was 0.90 for all species and 0.78 for native species only. Pine Lake had a rake diversity score of 0.75 for all species and 0.90 for natives only. Compared to Pearson's 2003 data, it appears that

Pine Lake has a very dense and diverse native plant population (Table 3). Figure 6 shows distribution and abundance of submersed vegetation and helps illustrate the dense plant population present in Pine Lake.

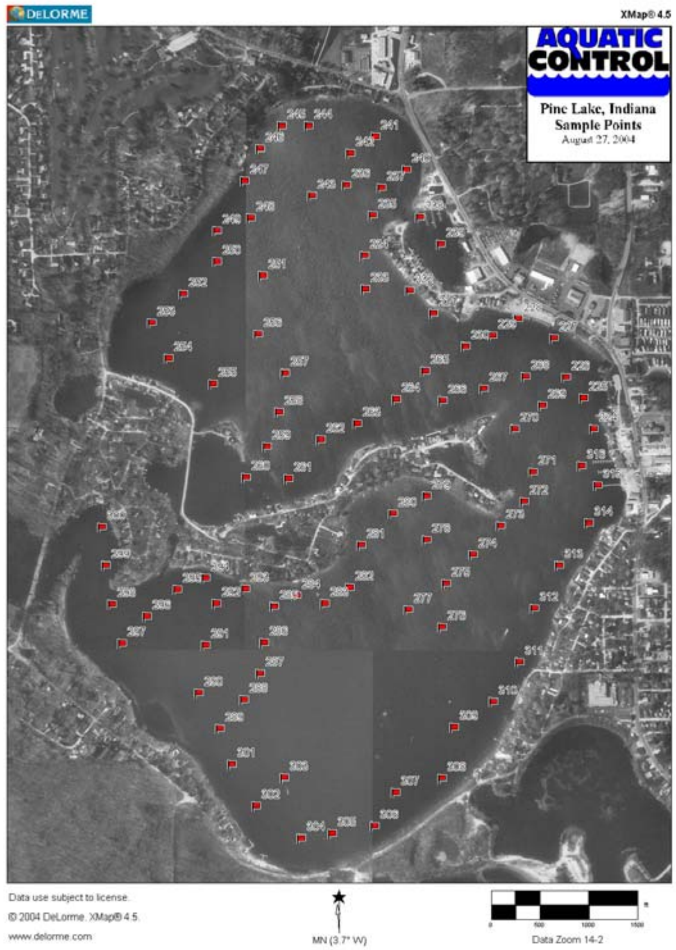

Figure 5. Tier II Sample Points (not to scale see appendix)

Table 3. Pine Lake vegetation abundance, density, and diversity metrics compared to average

	Pine Lake*	Average**
Percentage of sample sites with plants	96%	-
# of species collected	18	8
# of native species collected	17	7
Mean Rake Density	4.05	3.30
Rake Diversity (SDI)	0.87	0.62
Native Rake Diversity (SDI)	0.87	0.50
Species Richness (Avg # species/site)	3.91	1.61
Native Species Richness	3.90	1.33
Site Species Diversity	0.90	0.66
Site Species native diversity	0.90	0.56

*standard deviation not included
**average calculated from Pearson Data.

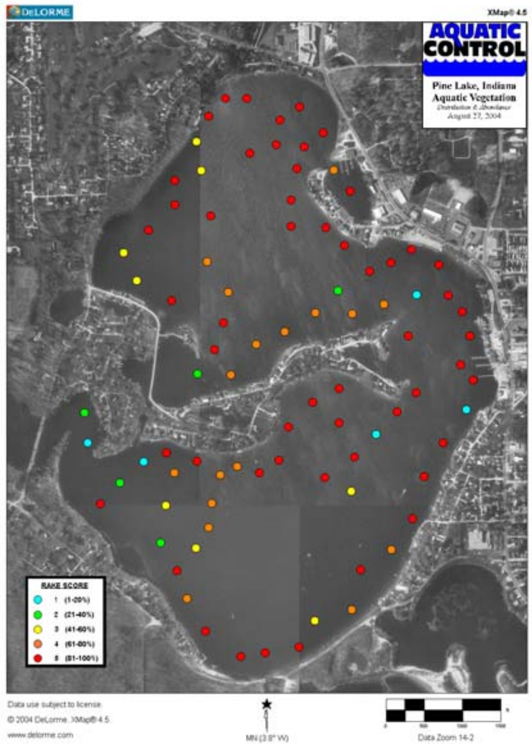

Figure 6. Aquatic vegetation distribution and abundance (not to scale see appendix)

Tier II sampling also allows for analysis of individual plant species. A total of 18 species were collected of which 17 of these species were natives (Table 4). Eurasian watermilfoil was the only exotic species collected. Eel grass was present in the highest percentage of sample sites (63.4%) (Figure 7), followed by largeleaf pondweed (52.7%) (Figure 8), fern pondweed (47.3%) (Figure 9), northern watermilfoil (46.2%) (Figure 10), slender naiad (40.9%) (Figure 11), variable pondweed (37.6%) (Figure 12), American elodea (32.3%) (Figure 13), coontail (24.7%) (Figure 14), water stargrass (18.3%), Richardson's pondweed (*Potamogeton richardsonnii*) (7.5%), broadleaf watermilfoil (7.5 %), bur marigold (5.4%) (Figure 15), and flatstem pondweed (5.4%). Sago pondweed was present at only two sites. Eurasian watermilfoil (Figure 16), chara, southern naiad (*Najas guadalupensis*), and leafy pondweed (*Potamogeton foliosus*) were collected at a single site.

Table 4. Species collected during Tier II sampling.

Common Name	Scientific Name	Frequency of Occurrence	Relative Density*	Dominance Index**
Eel grass	*Valisneria Americana*	63.4%	0.87	17.4
Largeleaf pondweed	*Potamogeton amplifolius*	52.7%	1.51	30.1
Fern pondweed	*Potamogeton robbinsii*	47.3%	0.83	16.6
Northern watermilfoil	*Myriophyllum sibircum*	46.2%	0.73	14.6
Slender naiad	*Najas flexilis*	40.9%	0.56	11.2
Variable pondweed	*Potamogeton gramineus*	37.6%	0.68	13.5
American elodea	*Elodea canadensis*	32.3%	0.38	7.5
Coontail	*Ceratophyllum demersum*	24.7%	0.27	5.4
Water stargrass	*Zosterella dubia*	18.3%	0.28	5.6
Richardson's pondweed	*Potamogeton richarsonii*	7.5%	0.09	1.7
Broadleaf watermilfoil	*Myriophyllum heterophyllum*	7.5%	0.09	1.7
Bur marigold	*Bidens beckii*	5.4%	0.06	1.3
Flatstem pondweed	*Potamogeton zosteriformis*	5.4%	0.05	1.1
Sago pondweed	*Potamogeton pectinatus*	3.2%	0.03	0.6
Eurasian watermilfoil	*Myriophyllum spicatum*	1.1%	0.05	1.1
Chara	*Chara spp.*	1.1%	0.01	0.2
Southern naiad	*Najas guadalupensis*	1.1%	0.01	0.2
Leafy pondweed	*Potamogeton foliosus*	1.1%	0.01	0.2

* Mean rake score at all sites
**Percent of maximum abundance

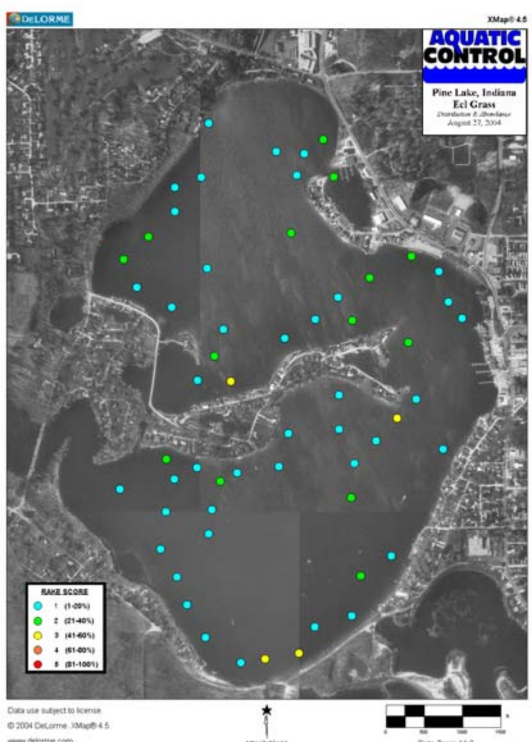

Figure 7. Eel grass distribution and abundance (not to scale see appendix)

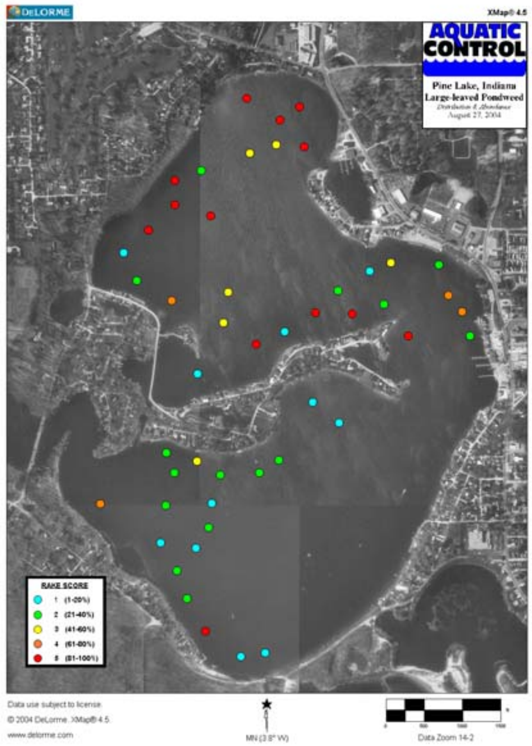

Figure 8. Largeleaf pondweed distribution and abundance (not to scale see appendix)

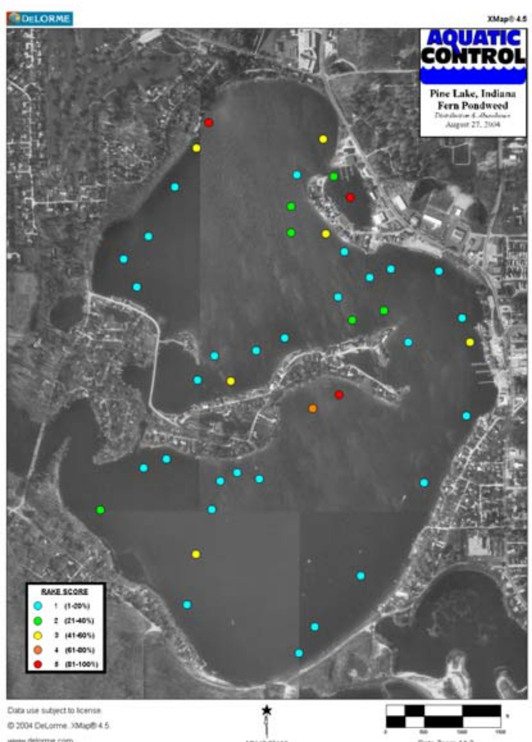

Figure 9. Fern pondweed distribution and abundance (not to scale see appendix)

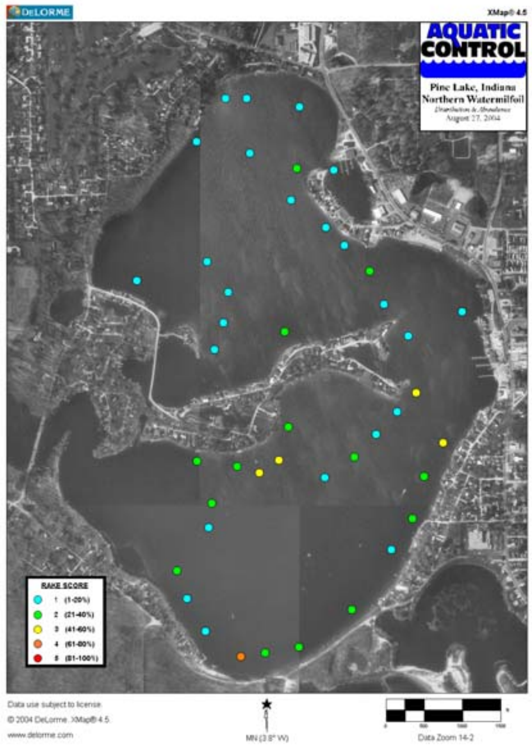

Figure 10. Northern watermilfoil distribution and abundance (not to scale see appendix)

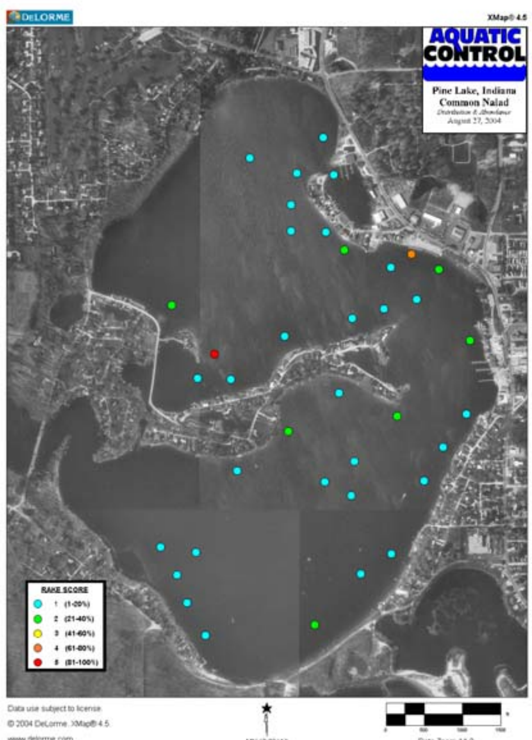

Figure 11. Slender naiad distribution and abundance (not to scale see appendix)

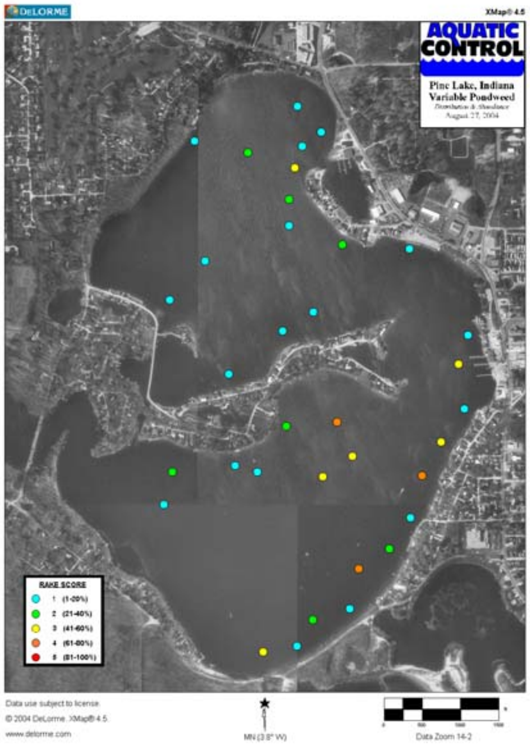

Figure 12. Variable pondweed distribution and abundance (not to scale see appendix)

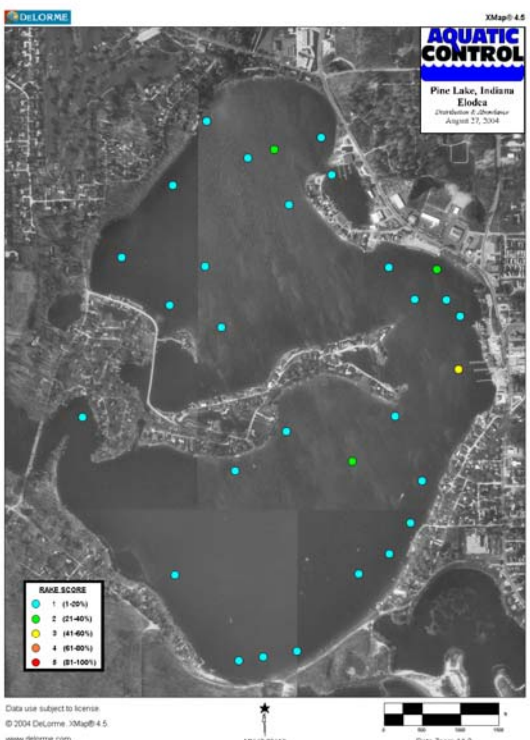

Figure 13. American elodea distribution and abundance (not to scale see appendix)

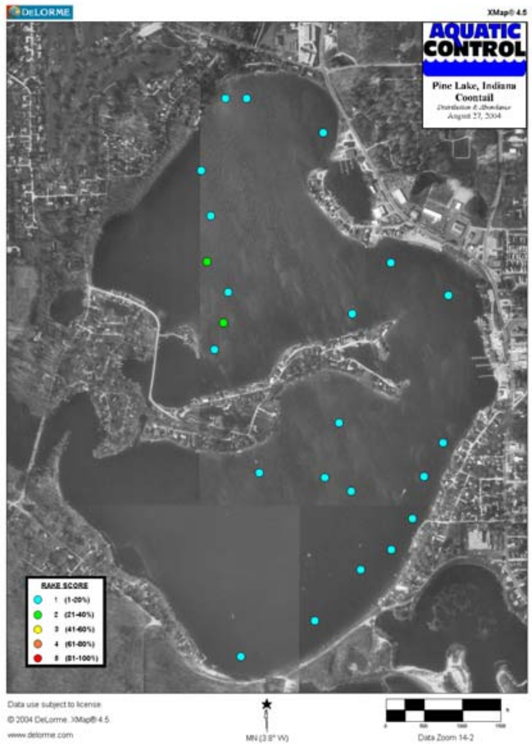

Figure 14. Coontail distribution and abundance (not to scale see appendix)

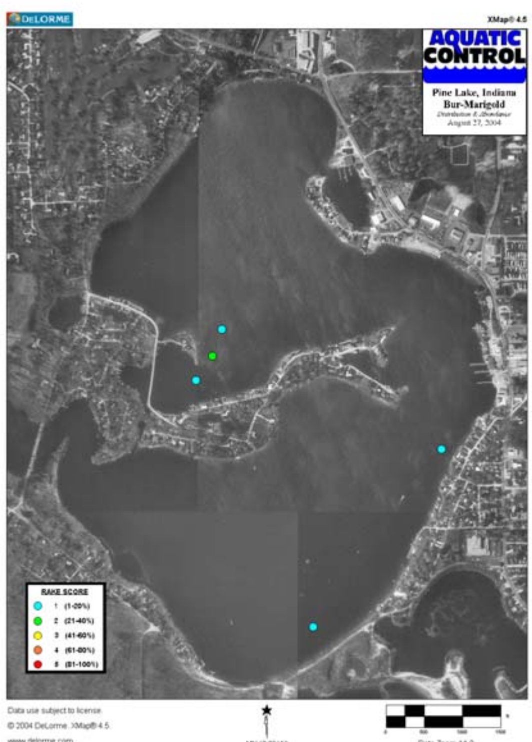

Figure 15. Bur marigold distribution and abundance (not to scale see appendix)

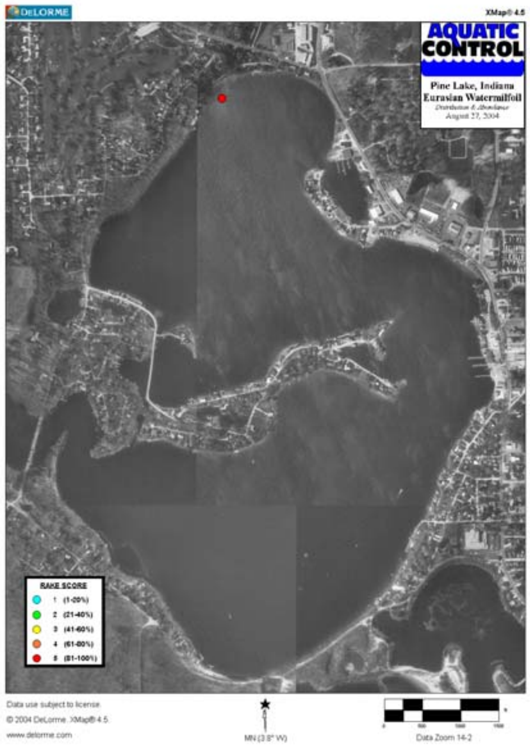

Figure 16. Eurasian watermilfoil distribution and abundance (not to scale see appendix)

Plant Management History

Historically, plant management activity at Pine Lake has consisted of individual lot herbicide treatments with contact herbicides. Recently, the Laporte Area Lake Association has taken the responsibility for collecting money for these individual lot treatments in an effort to organize plant management activities. In 2003, one treatment was completed by Aquatic Control Inc. in order to obtain control of vegetation which was interfering with boat access and swimming activity. This treatment consisted of 20 acres scattered around the shoreline of Pine Lake. Some regrowth occurred following this treatment, so in 2004 two treatments were completed in order to prevent regrowth (Figure 17).

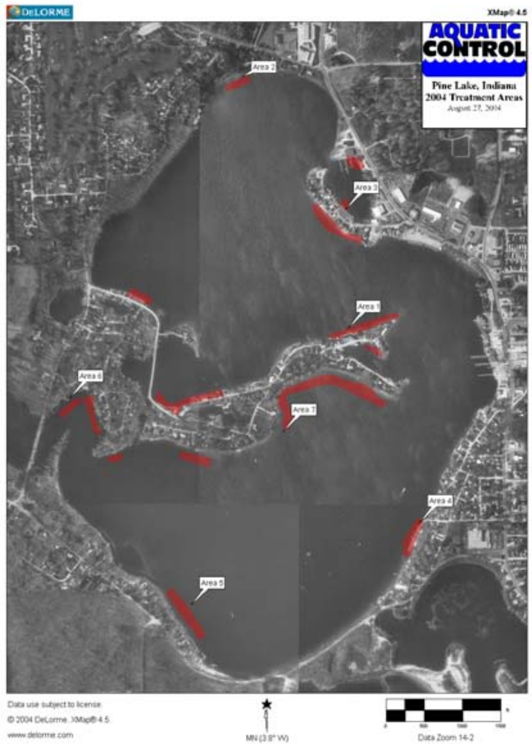

Figure 17. 2004 Pine Lake treatment areas.

Aquatic Plant Management Alternatives

The main nuisance aquatic vegetation within Pine Lake at the time of the survey were native species. However, these species were only creating nuisance conditions in high use areas mainly by blocking boat access and swimming areas in front of homes and docks. There remained a large percentage of open water for water skiing, swimming, and fishing where vegetation was not reaching the surface.

The exotic species Eurasian watermilfoil was collected at only one site during the Tier II survey, but was observed at low densities at other locations during the Tier I survey. This species should be closely monitored and controlled following a spring survey in order to prevent it from spreading throughout the lake competing with native vegetation and causing nuisance conditions. It is believed that Eurasian watermilfoil was first introduced from Eurasia or North Africa to an area near Maryland around 1942, possibly through the aquarium trade. Some reports suggest that this species may have been introduced into North America as early as the late 1800's through shipping ballast (Ditomaso & Healy, 2003). This species has now spread throughout the majority of North America and is the primary nuisance submersed aquatic species in Indiana. Once established, growth and physiological characteristics of Eurasian watermilfoil enable it to form a surface canopy and develop into immense stands of weedy vegetation, out competing most submersed species and displacing the native plant community (Madsen et al., 1988). Eurasian watermilfoil can also have negative impacts on fish populations.

In order to develop a scientifically sound and effective action plan, all aquatic management alternatives need to be considered. The alternatives that will be discussed include: no action; environmental manipulation; chemical, mechanical, or biological control methods; and any combination of these methods.

A number of different techniques have been successfully used to control nuisance submersed vegetation. These techniques vary in terms of their efficacy, rapidity, and selectivity, as well as the thoroughness and longevity of control they are capable of achieving. Each technique has advantages and disadvantages, depending on the circumstances. Selectivity is a particularly important characteristic of control techniques. Nearly all aquatic plant control techniques are at least somewhat selective, in that they affect some plant species more than others. Even techniques such as harvesting that have little selectivity within the areas to which they are applied can be used selectively, by choosing only certain areas in which to apply them. Selectivity can also occur after the fact, as when a technique controls all plants equally but some grow back more rapidly. One facet of selecting an appropriate aquatic plant control technique is matching the selectivity of the control technique with the goals of aquatic plant management. When controlling Eurasian watermilfoil, for example, it is typically desirable to use techniques that control Eurasian watermilfoil with minimal impact on most native species (Smith, 2002). At the end of this section, Table 5 summarizes the various control techniques.

No Action

What if no aquatic plant management activity took place on Pine Lake? Limited contact herbicide treatments have taken place for the last several years in order to reduce nuisance conditions in front of docks and swimming areas. If no action were taken these nuisance conditions would continue throughout the summer season limiting dock access and interfering with swimming areas. Eurasian watermilfoil could spread and displace native vegetation. This species could also increase nuisance conditions to other areas in the lake.

Environment manipulation

Environmental manipulation for Pine Lake would include water level draw-down. Drawdown is usually conducted in the winter months so that plants are exposed to both drying and freezing. This method effects species differently and is highly variable depending on the amount of freezing and thawing which occurs. Pine Lake is currently experiencing drawdown due to a low water table. This has allowed vegetation to grow in what used to be deeper water areas. If the lake level returns to normal conditions next season, nuisance conditions may not occur in areas which had been exposed to freezing and thawing during the winter months. There is no means to physically draw down this lake.

Mechanical

Mechanical control includes cutting, dredging, or tilling the bottom sediments to eliminate aquatic plant growth. The main advantage to mechanical control is the immediate removal of the plant growth from control areas and the removal of organic matter and nutrients.

One of the most common mechanical control techniques used on larger lakes in Indiana is mechanical harvesting. Mechanical harvesting uses machines which cut plant stems and, in most cases, pick up the cut fragments for disposal. This type of mechanical control has little selectivity. Where a mix of Eurasian watermilfoil and native species exists, harvesting favors the plant species that grow back most rapidly following harvesting. In most cases, Eurasian watermilfoil recovers from harvesting much more rapidly than native plants. Thus, repeated harvesting hastens the replacement of native species by Eurasian watermilfoil and often leads to dense monocultures of Eurasian watermilfoil in frequently harvested areas. Harvesting also stirs up bottom sediments thus reducing water clarity, kills fish and many invertebrates, and hastens the spread of Eurasian watermilfoil via fragmentation. For these reasons, large scale harvesting is not recommended as a primary control method. However, lakeside property owners are allowed to remove vegetation in a 625 square foot area. This is an alternative to residents who are opposed to having their shorelines chemically treated.

Biological

Biological controls reduce aquatic vegetation using other organisms that consume aquatic plants or cause them to become diseased (Smith, 2002). The main biological controls for aquatic vegetation used in Indiana are the white amur (grass carp). The milfoil weevil has been used in an attempt to control Eurasian watermilfoil.

The white amur or grass carp *Ctenopharyngodon idella* is a herbivorous fish imported from Asia. Triploid grass carp, the sterile genetic derivative of the diploid grass carp, are legal for sale in Indiana. Grass carp tend to produce all or nothing aquatic plant control. It is very difficult to achieve a stocking rate sufficient to selectively control nuisance species without eliminating all submersed vegetation. They are not particularly appropriate for Eurasian watermilfoil control because Eurasian watermilfoil is low on their feeding preference list; thus, they eat most native plants before consuming Eurasian watermilfoil (Smith, 2002). Grass carp are also difficult to remove from a lake once they have been stocked. Grass carp are not recommended for vegetation control in Pine Lake.

The milfoil weevil, *Euhrychiopsis lecontei*, is a native North American insect that consumes Eurasian and Northern watermilfoil. The weevil was discovered following a natural decline of Eurasian watermilfoil in Brownignton Pond, Vermont (Creed and Sheldon, 1993), and has apparently caused declines in several other water bodies. Weevil larvae burrow in the stem of Eurasian watermilfoil and consume the vascular tissue thus interrupting the flow of sugars and other materials between the upper an lower parts of the plant. Holes where the larvae burrow into and out of the stem allow disease organisms a foothold in the plants and allow gases to escape from the stem, causing the plants to lose buoyancy and sink (Creed et al. 1992).

Concerns about the use of the weevil as a biological control agent relate to whether introductions of the milfoil weevil will reliably produce reductions in Eurasian watermilfoil and whether the resulting reductions will be sufficient to satisfy users of the lake (Smith, 2002). Following our research, no conclusive data concerning the role of weevils in reducing Eurasian watermilfoil populations has been made available. In 2003, Scribailo & Alix conducted a weevil release study on three Indiana lakes and had no conclusive evidence supporting the use of weevils in reducing milfoil populations. Weevils may reduce milfoil populations in some lakes, but predicting which lakes and how much, if any, control will be achieved has not been documented.

Chemical Control

Chemical control uses chemical herbicides to reduce or eliminate aquatic plant growth. The main advantage of using herbicides is their overall effectiveness. The public's main concern over herbicide use is safety. This should not be a concern due to the extensive testing which is required prior to herbicide being approved for use in the aquatic environment. These tests ensure that the herbicides are low in toxicity to human and animal life and they are not overly persistent or bioaccumulated in fish or other organisms. Certain herbicides require short term water-use restrictions such as irrigation, fishing, and domestic use. These restrictions must be posted prior to application.

There are two different types of aquatic herbicides; systemic and contact. Systemic herbicides are translocated throughout the plants and thereby kill entire plants. Fluridone (trade name Sonar & Avast!) can effectively control most aquatic plant species, and at the correct rate fluridone can selectively control Eurasian watermilfoil. 2,4-D (trade name Navigate, Aqua-Kleen, & DMA4 IVM), and trichlopyr (trade name Renovate) are systemic herbicides that can effectively control Eurasian watermilfoil.

Based upon the author's experience and personal communication with a vast array of North American aquatic plant managers, whole-lake fluridone applications are by far the most effective means of controlling Eurasian watermilfoil. Successful fluridone treatments yield a dramatic reduction in the abundance of Eurasian watermilfoil, often reducing it to the point that Eurasian watermilfoil plants are difficult to detect following treatment (Smith, 2002). An advantage to using fluridone over most contact herbicides is its selectivity. Most strains of Eurasian watermilfoil have a lower tolerance to fluridone than the majority of native species, so if the proper rates are applied Eurasian water milfoil can be controlled with little harm to the majority of native species. The disadvantage to a whole lake fluridone treatment is the one-time cost. This type of treatment is not necessary on Pine Lake due to the limited amount of Eurasian watermilfoil, which appears to be isolated in one area.

Triclopyr is a systemic herbicide that has recently been approved for use in aquatics. Triclopyr typically is used for treating isolated milfoil beds as opposed to whole lake treatments. This herbicide is very selective to Eurasian watermilfoil. A study was completed in 1997 which focused on triclpyr's effects on Eurasian watermilfoil and native vegetation. The study found Eurasian watermilfoil biomass was reduced by 99%

in treated areas at 4 weeks post-treatment, remained low one year later, and was still at acceptable levels of control at two years post-treatment. Non-target native plant biomass increased 500-1000% by one year post-treatment, and remained significantly higher in the cove plot at two years post-treatment. Native species diversity doubled following herbicide treatment, and the restoration of the community delayed the re-establishment and dominance of Eurasian watermilfoil for three growing season (Getsinger et. al., 1997). Triclopyr is a good alternative to fluridone when Eurasian watermilfoil is not abundant throughout an entire water body.

Applied properly, 2,4-D can also yield major reductions in the abundance of Eurasian watermilfoil, but long-term reductions are more difficult to achieve using 2,4-D than using whole-lake fluridone applications. Treatments must be even and dose rates accurate. Under the best circumstances, some areas will probably need to be treated repeatedly before the Eurasian watermilfoil in them is controlled. Also, the difficulty of finding and treating areas of sparse Eurasian watermilfoil makes it likely that Eurasian watermilfoil will be reestablished from plants surviving in these areas (Smith 2002). This formulation should be used much like Triclopyr, but the same results may not occur. Unlike Triclopyr, 2,4-D can impact the native species coontail.

Contact herbicides can also be effective for controlling submersed vegetation in the short term. The three primary contact herbicides used for control of submersed vegetation are diquat (trade name Reward), endothal (trade name Aquathol), and copper based formulations (trade names Komeen, Nautique, and Clearigate).

Historically, a drawback to the use of contact herbicides has been the lack of selectivity exhibited by these herbicides. However, a study recently completed by Skogerboe and Getsinger outlines how endothal can be used for control of the exotic species curlyleaf pondweed and Eurasian watermilfoil with little effect on the majority of native species. They found early season treatments with endothall effectively controlled Eurasian watermilfoil and curlyleaf pondweed at several application rates with no regrowth eight weeks after treatment. Sago pondweed, eel grass, and Illinois pondweed (*Potamogeton illinoensis*) biomass were also significantly reduced following the endothall application, but regrwoth was observed at eight weeks post-treatment. Coontail and elodea showed no effects from endothall at three of the lower application rates. Yellow pond lily, pickerelweed (*Pontederia cordata*), cattail (*Typha spp.*), and smartweed (*Polygonum spp.*) were not injured at any of the application rates (Skogerboe & Getsinger 2002). This type of treatment strategy could be applied to lakes that have large areas of both curlyleaf pondweed and Eurasian watermilfoil. However, the one drawback to the use of endothal is a 3-day fish harvest restriction which is currently under review by U.S. E.P.A. This restriction may be removed in the next few years. Endothal could also be effective the year after whole lake fluridone treatments where curlyleaf pondweed typically returns the following season.

Diquat and many of the copper formulations are effective fast acting contact herbicides. These formulations are typically used when control of all submersed vegetation is desired. Aquatic Control uses these herbicides for control of nuisance vegetation around docks and near-shore high-use areas. A drawback to the use of these herbicides is the lack of selectivity and quick recovery time.

Table 5. Comparison of vegetation control techniques for Pine Lake.

Control Method	Advantages	Disadvantages	Conclusion
No Action	No cost and less controversy	No plant control, degradation of fish habitat, difficult boating, and spread of exotic plant species.	Something should be initiated to prevent spread of milfoil and reduce nuisance conditions.
Environmental Manipulation (drawdown)	Low cost, compaction of flocculent sediments, may get control of some nuisance species, and less controversial.	Unpredictable plant control, exposes desirable plants and animals to freezing and thawing, dependent on good freeze, could impede recreation, dependent on spring rains to raise water level or lack of precipitation in winter to lower water level.	Not possible to sufficiently lower lake and may damage beneficial natives.
Mechanical (cutting, dredging, or tilling)	Low cost, less controversy, can target areas of desired control, removes organics.	Possibility of spreading exotic vegetation, labor intensive, damage to fish and other aquatic organisms, and harvesting can promote increased milfoil growth.	Not good option due to potential spread of exotics. Could possibly be used on small-scale initial infestation or post-treatment.
Biological Control (milfoil weevil)	No chemical needed, naturally occurring native species, no use restrictions following application, selective for Eurasian watermilfoil, and known to cause fatal damage to plant	Studies have been inconclusive on the effectiveness and cost is relatively high compared to most other control methods.	No proof that this method is effective. Too large of an investment for unproven method.
Biological Control (Grass Carp)	No chemical needed, no use restrictions following application, no reproduction, and proven to consume aquatic vegetation.	Prefers many of the native species over exotic species, non-native fish species, tend to move downstream, once they are introduced they are nearly impossible to remove.	Not a good option due to inability to remove once stocked and preference for native vegetation.
Chemical Control	Proven safe and effective technique, can be selective, relatively easy application, and fast results.	Higher cost than most techniques, public concern over chemicals, build-up of dead plant material following application, and lake use restrictions	Proven to be effective with minimal use restrictions very effective Eurasian watermilfoil control

Action Plan

The Association has set three aquatic vegetation management goals:

1. Prevent further water use impairment by nuisance aquatic plants while minimizing the negative impacts on fish and wildlife resources.

2. Maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality, and is resistant to minor habitat disturbances and invasive species.
3. Promote the use of environmentally sound aquatic plant management techniques with control efforts focused on invasive species.

The exotic species Eurasian watermilfoil was found at only one location in Pine Lake during the Tier II sampling, but found at low densities throughout the lake during Tier I sampling (Figure 16). Plant sampling should be initiated in the spring of 2005 in order to locate all areas of Eurasian watermilfoil. After these areas are located Eurasian watermilfoil should be treated with a systemic herbicide in order to control this species and prevent its spread. Current plant management efforts focus only on the control of nuisance aquatic vegetation. Eurasian watermilfoil should be controlled before it reaches nuisance levels.

At a November public lake user meeting, concern was raised over the interference caused by submersed native vegetation. This vegetation has restricted boating, swimming, and fishing. A great deal of concern was voiced over swimmer safety (swimmers can become entangled in dense submersed vegetation). High-use areas should be managed in an effort to reduce the negative impacts of submersed vegetation. This will likely require two herbicide applications to these select areas on an annual basis. Endothal should be used for the spring treatment in order to more effectively control a variety of pondweed species. Diquat should be used in nuisance areas in summer. Diquat herbicide is a good short-term control for the majority of pondweed species, but is much more effective than endothal at controlling naiad species which reach nuisance levels in some of the high use areas. This part of the action plan is similar to the herbicide application which took place in 2004. Exact acreages and herbicides should be determined following plant surveys which should be completed in the spring and late summer. However, based on past contact treatments, it is likely that up to 20 acres may require herbicide application (see Figure 17 in Plant Management History). In following years, the action plan may need adjusted as new more effective herbicides become approved for aquatic use.

One of the most important aspects of the action plan is the plant sampling. A Tier I and Tier II survey should be completed in May of 2005. Another Tier II survey should be completed in August. The spring survey will document the abundance and density of curlyleaf pondweed, which may be creating more problems than observed during the August sampling. This sampling will also allow the location of Eurasian watermilfoil to be documented prior to treatment. The August sampling will document the effects of plant management activities and help to determine changes which may be needed in 2006.

The initiation of this action plan will allow Eurasian watermilfoil to be controlled at a very early stage of invasion. Early treatment of this species should help save money in the long run and prevent Eurasian watermilfoil from negatively impacting native plant species and the fishery. This action plan will also allow for the control of nuisance species in high-use areas while leaving a healthy amount of native vegetation for fish cover. Table 6 includes budget estimates for plant sampling and vegetation control.

Table 6. Budget estimates for management options

	2005	**2006**	**2007**
Eurasian watermilfoil herbicide*	$8,000*	$6,000*	$4,000*
Herbicide & Application Cost	$12,000	$12,000	$12,000
Vegetation Sampling & Plan Update*	$3,400*	$3,400*	$3,400*
Total:	**$23,400***	**$21,400***	**$19,400***

*Eligible for Lare Funding, Eurasian watermilfoil estimate based on treating 20 acres with triclopyr the first season (based on spring visual survey), with 15 acres in 2006 and 10 acres in 2007.

Education

It is important that all lake users, lake residents, and other stakeholders participate and be informed about the lake management activities. A public meeting was conducted on November 22, 2004 in order to obtain user input concerning aquatic vegetation problems and action which could be initiated. Each winter a similar meeting should take place to discuss necessary changes in the plan and to update lake users of changes and activities. Information discussing aquatic vegetation management activities and treatment restrictions should be posted in high use areas around the lake. Signs should be posted at the boat ramp warning people about the dangers of transporting exotic vegetation. Signs should also be posed in treatment areas listing restrictions due to herbicide application. Additional information concerning aquatic vegetation management can be obtained at the following web sites: www.mapms.org, www.aquatics.org, www.apms.org, www.aquaticcontrol.com, or www.nalms.org. Concerns have been raised over the safety of aquatic herbicides. These herbicides have been extensively tested by the U.S. E.P.A. Information about these testing procedures can be obtained from www.epa.gov/pesticides.

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Appendix A. Macrophyte List for Pine Lake

Common Name	Scientific Name	IDNR 2000	Tier I Survey	Tier II Survey
American elodea	*Elodea canidensis*	X	X	X
Broadleaf watermilfoil	*Myriophyllum heterophyllum*		-	X
Bur marigold	*Bidens beckii*	X	X	X
Chara	*Chara spp.*	X	X	X
Cattail	*Typha spp.*	X	-	-
Common bladderwort	*Utricularia vulgaris*	X	-	-
Coontail	*Ceratophyllum demersum*	X	X	X
Curlyleaf pondweed	*Potamogeton crispus*	X	-	-
Eel grass	*Valisneria americana*	X	X	X
Eurasian watermilfoil	*Myriophyllum spicatum*	X	X	X
Fern pondweed	*Potamogeton robbinsii*	-	X	X
Flatstem pondweed	*Potamogeton zosteriformis*	-	X	X
Largeleaf pondweed	*Potamogeton amplifolius*	X	X	X
Leafy pondweed	*Potamogeton foliosus*	X	-	X
Northern watermilfoil	*Myriophyllum sibircum*	X	X	X
Richardson's pondweed	*Potamogeton richardsonii*	X	-	X
Sago pondweed	*Potamogeton pectinatus*	X	X	X
Slender naiad	*Najas flexilis*	X	X	X
Small pondweed	*Potamogeton pusillus*	X	-	-
Southern naiad	*Najas guadalupensis*	-	-	X
Variable pondweed	*Potamogeton gramineus*	-	X	X
Water stargrass	*Zosterella dubia*	-	X	X
White water lily	*Nymphaea tuberosa*	-	X	-
Whorled watermilfoil	*Myriophylum verticillatum*	X	-	-
Spatterdock	*Nuphar spp.*	X	X	-

American elodea (*Elodea canadensis*) is a bright green submersed monocot with three leaves whorled about the stem[2]. The leaves curve back and are rounded at the tips[1]. Elodea is a wildlife food of varying importance[2]. It can shelter smaller aquatic life, is sparingly eaten by muskrats, and may suppress other plants[2.] Elodea can be important to the fishery of a lake due to its ability to shelter and support insects that can be used in fish production[2].

Chara (*chara spp.)* is an anchored green algae with whorled, branchlike filaments at the nodes of a central axis. Often times mistaken for vascular plants. Typically inhabits shallow water. Provide food and cover for wildlife. Rarely reaches the surface of the water and rarely causes problem.

Coontail (*Ceratophylum demersum*) is a commonly occurring aquatic plant in the Midwest in neutral to alkaline waters[1]. It is a submersed dicot with coarsely toothed leaves whorled about the stem[2]. This plant is given its name due to its resemblance to the tail of a raccoon. Coontail has been found to be an important food source for wildfowl as well as a good shelter for small animals[2]. This plant is also a good shelter for young fish,

Curlyleaf pondweed (*Potamogeton crispus*) is a submersed monocot with slightly clasping, rounded tip leaves. The flowers occur on dense cylindrical spikes and produces distinctive beaked fruit[1]. Curly leaf is eaten by ducks, but may become a weed[2]. This plant provides good food, shelter, and shade for fish and is important for early spawning fish like carp and goldfish[2].

Eel grass (*Valisneria americana*) is also referred to as tape grass. This submersed plant is dioecious and has linear submerged or floating leaves that are strap-or tape-shaped. This plant has not been documented from any plant surveys but has been seen by the Author floating in Webster Lake. This plant was also listed on several permit applications in the mid-1980's.

Eurasian water-milfoil (*Myriophyllum spicatum*) is an exotic aquatic plant that has been known to crowd out native species of plants. This species spreads quickly because it can grow from very small plant fragments and survive in low light and nutrient conditions[3]. This dicot has stems that typically grow to the water surface and branch out forming a canopy that shades other species of aquatic plants. Eurasian water-milfoil has characteristic red to pink flowering spikes that protrude from the water surface one to two inches high[1]. The segmented leaves grow in whorls of three to four around the stem[1]. This exotic plant is easily differentiated from its native relative, northern milfoil, by stem growth and the numbers of sections per leaf.

Largeleaf pondweed (*Potamogeton amplifolius*) is a submersed to floating attached monocot with folded, ovate, sickle shaped upper leaves and lanced shaped underwater leaves that are usually not folded[1]. Flowers occur on dense cylindrical spikes[1]. This plant supports insects and is a good food supply for fish[2]. Large-leaved pondweed is a desirable duck food[2].

Leafy pondweed (*Potamogeton foliosus*) is a submersed monocot with long, narrow leaves and flowers in rounded to short cylindrical spikes[1]. This plant is often important for wildfowl and provides good cover and food for fish[2].

Sago pondweed (*Potamogeton pectinatus*) is a submersed monocot with leaves that are threadlike to narrowly linear that form a sheath around the stem[1]. The nutlet and tubers

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[1] Chadde, S. 1998. Great lakes wetland flora. Pocketflora Press, Calumet, Michigan.
[2] Fassett, N. 1957. A manual of aquatic plants, 2nd edition. The University of Wisconsin Press, Madison, Wisconsin.
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of this plant make it the most important pondweed for ducks[2]. It also provides food and shelter for young trout and other fish[2]. This species can produce thick nuisance growth in shallow near-shore areas of lakes.

Small pondweed (*Potamogeton pusillus*) is a submersed monocot with slender, long leaves. Its fruit is green to brown and has a flat beak[1]. This plant provides fish with good cover and food and is a good food source for wildfowl[2]. This species has a propensity for developing nuisance conditions when competition from other species is not present.

White water lily (*Nymphaea tuberosa*) is a floating attached dicot that grows from tubers and produces broad, deeply lobed floating leaves and white flowers[1]. This plant produces seed that is fair food for wildfowl[2]. The root stocks and petiole bases are eaten by muskrats and the "roots" are eaten by beaver, deer, moose, and porcupine[2]. White water lilies can provide good habitat for fish, but can induce a negative value when too dense[2].
.

Spatterdock (*Nuphar spp.*) is an emergent dicot with broad, deeply lobed leaves emerging from the water[1]. This plant has distinctive large yellow flowers emanating from spikes. Spatterdock produces seeds and rootstocks that are used by wildfowl, beaver, moose and porcupine[2]. This plant attracts wildfowl and marsh birds and the bases of the petioles are eaten by muskrats[2]. Spatterdock is a poor producer of food for fish, but provides good shade and shelter[2].

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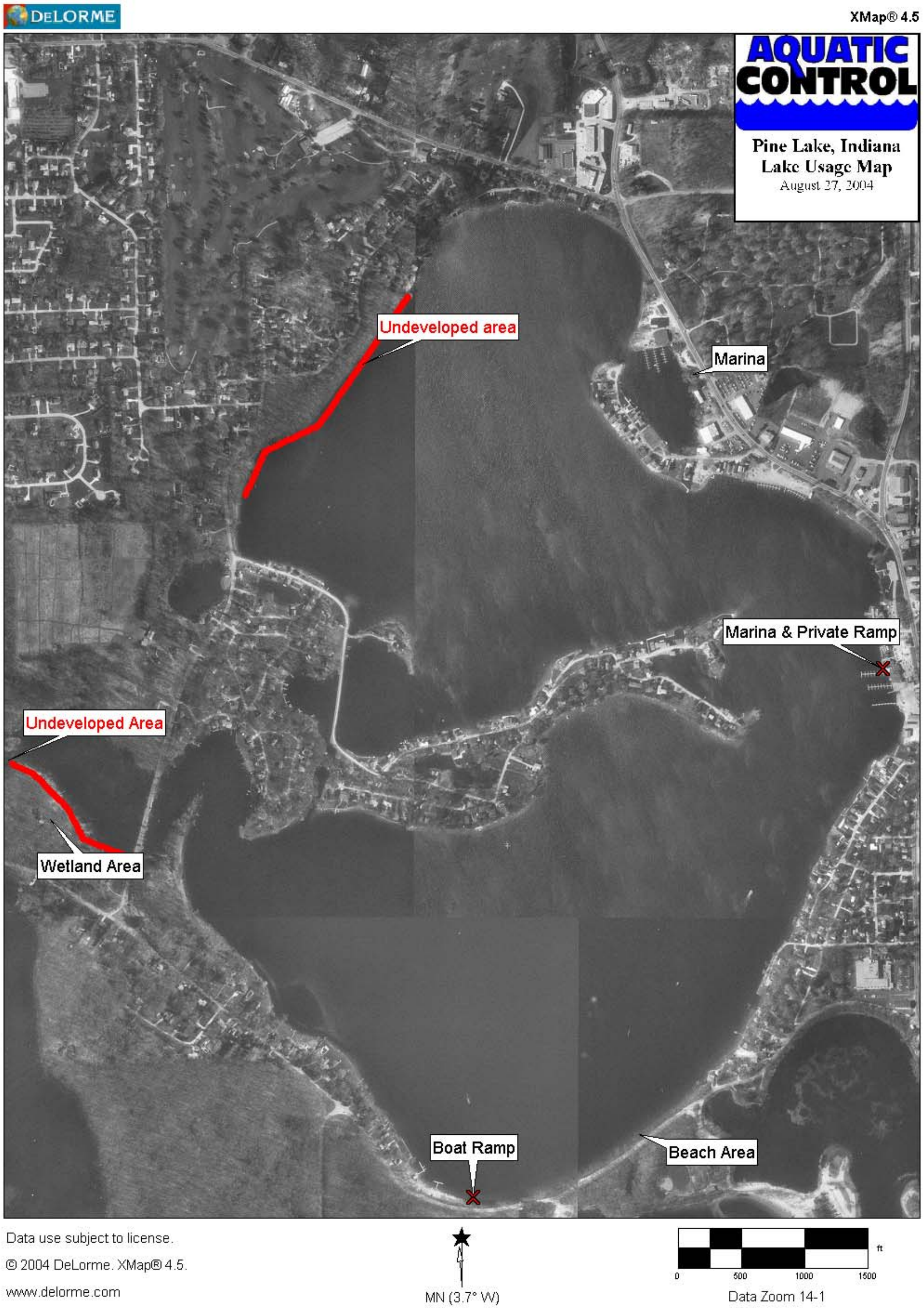
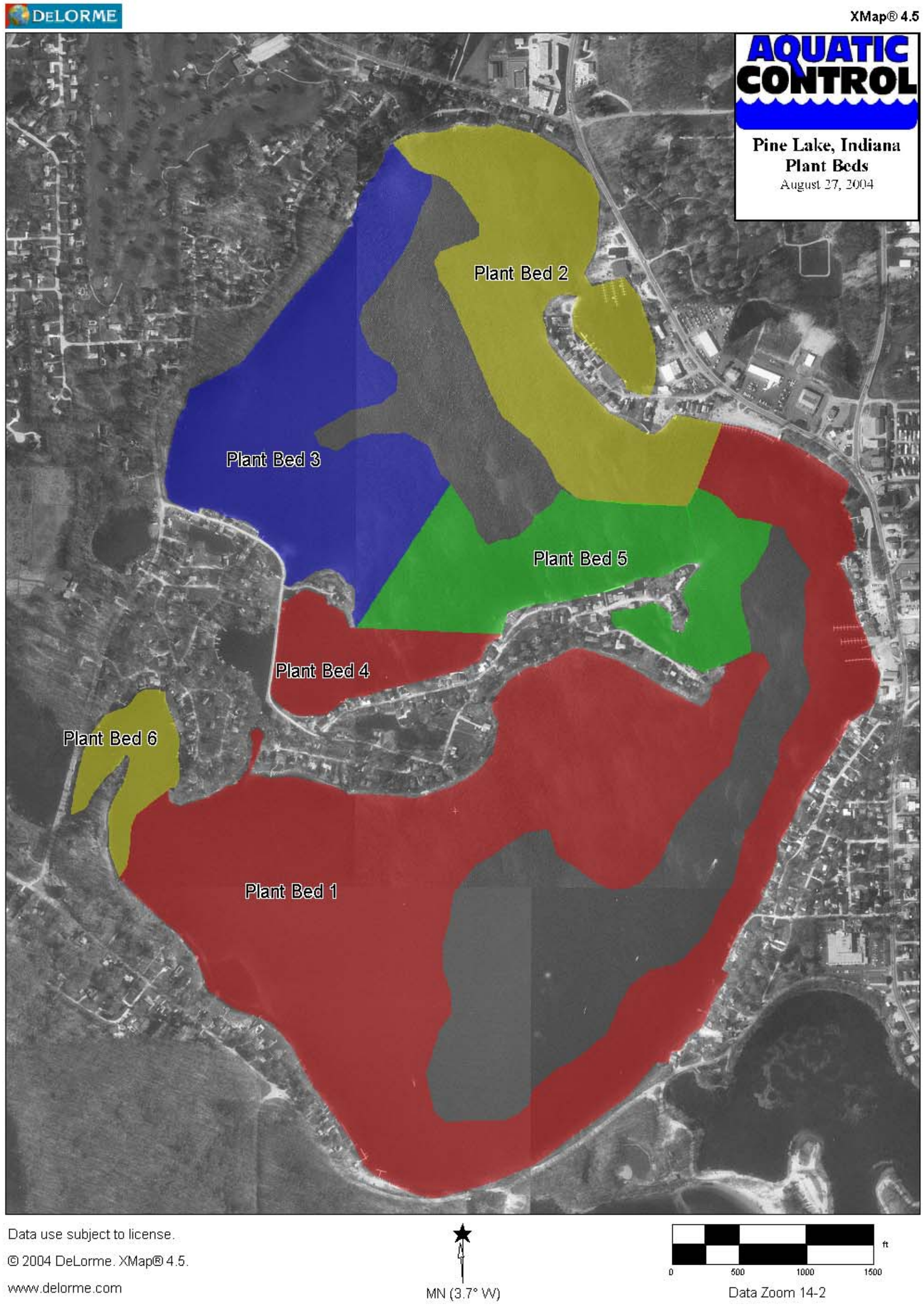
[1] Chadde, S. 1998. Great lakes wetland flora. Pocketflora Press, Calumet, Michigan.
[2]Fassett, N. 1957. A manual of aquatic plants, 2nd edition. The University of Wisconsin Press, Madison, Wisconsin.[1]
[3]Applied Biocehmists, 1998. Water weeds and algae, 5th edition. Applied Biochemists, J. C. Schmidt and J. R. Kannenberg, editors. Milwaukee, Wisconsin.

Appendix B. Maps

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XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Plant Beds
August 27, 2004
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Plant Bed 5
Plant Bed 4
Plant Bed 6
Plant Bed 1
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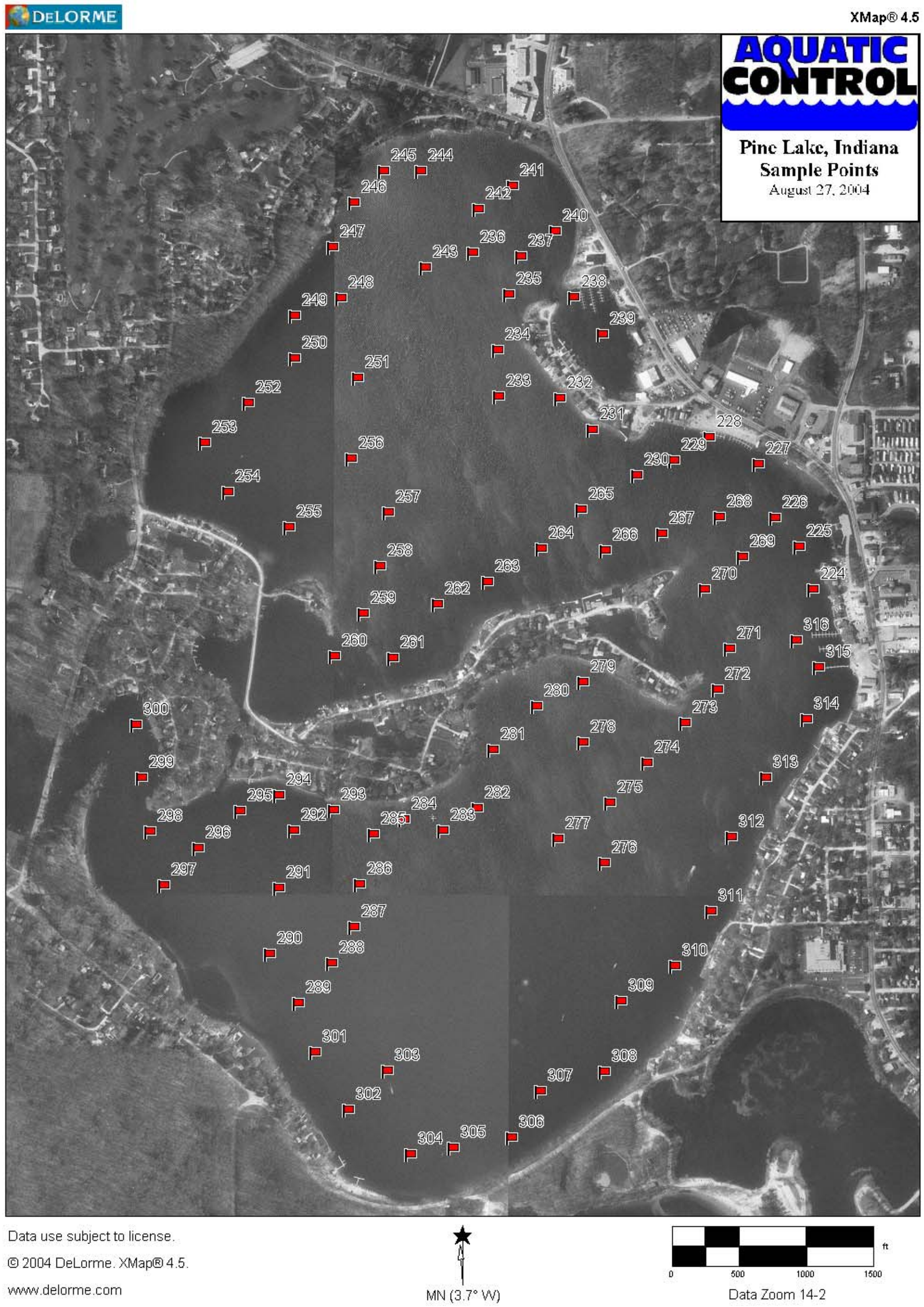
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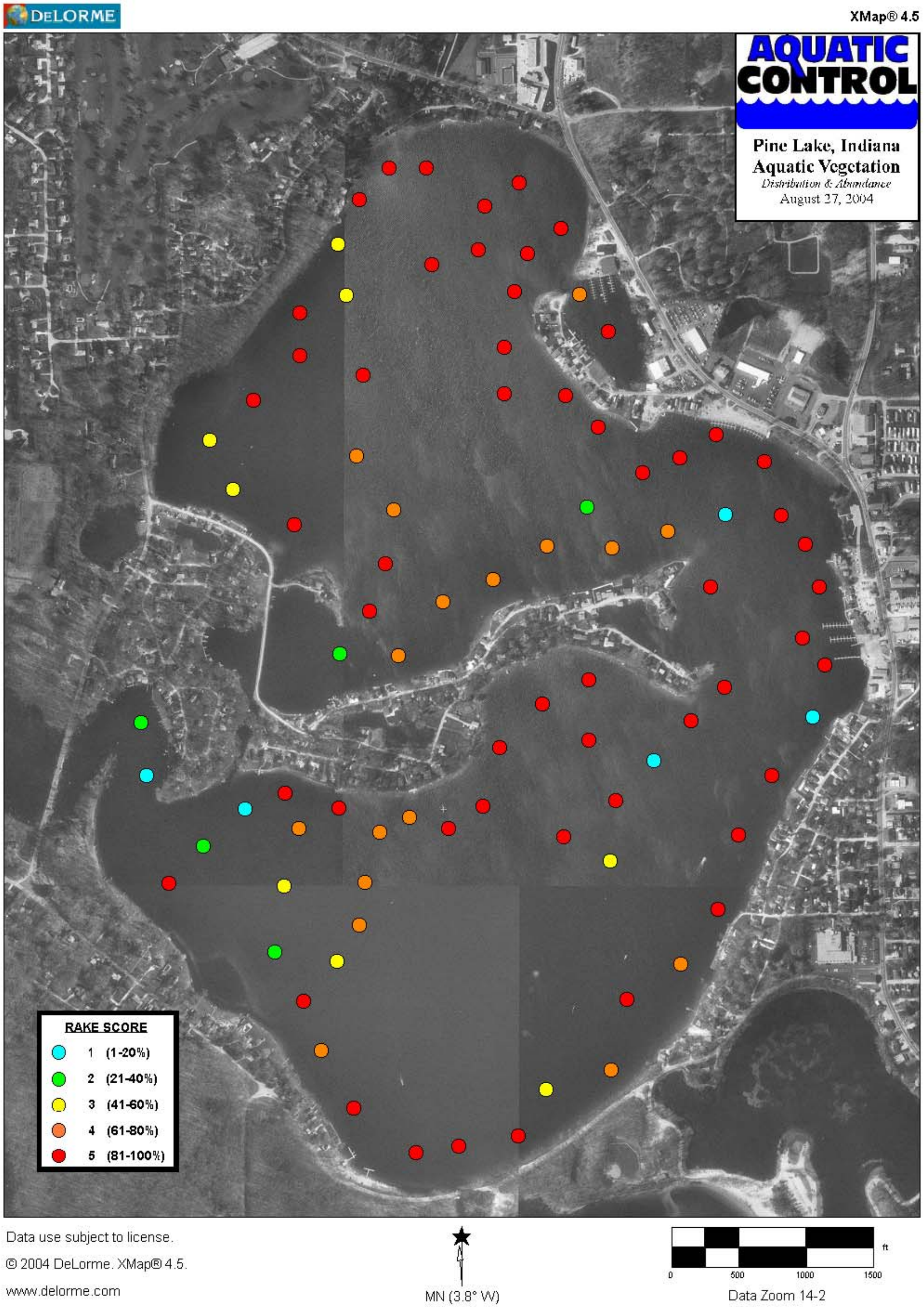
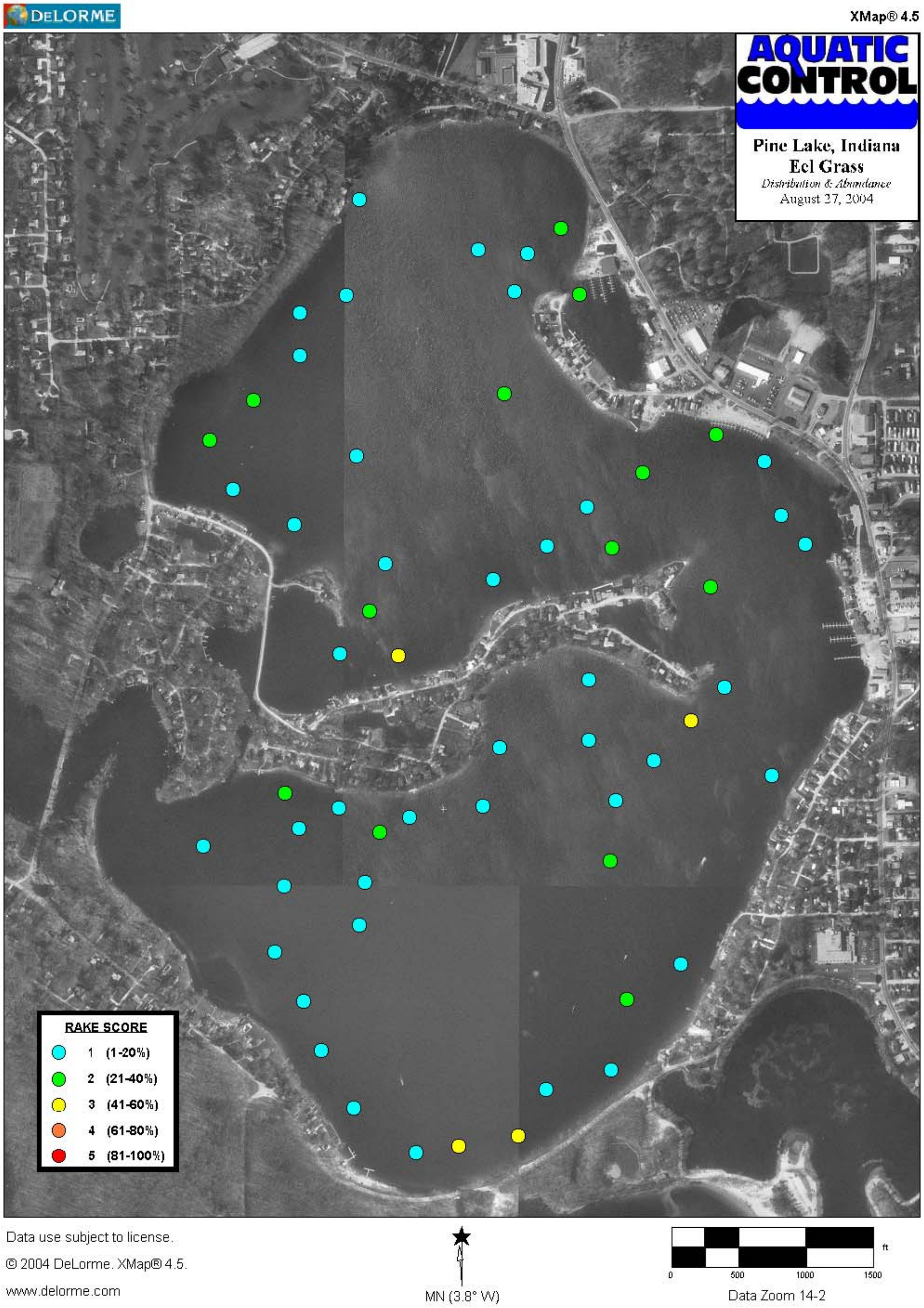
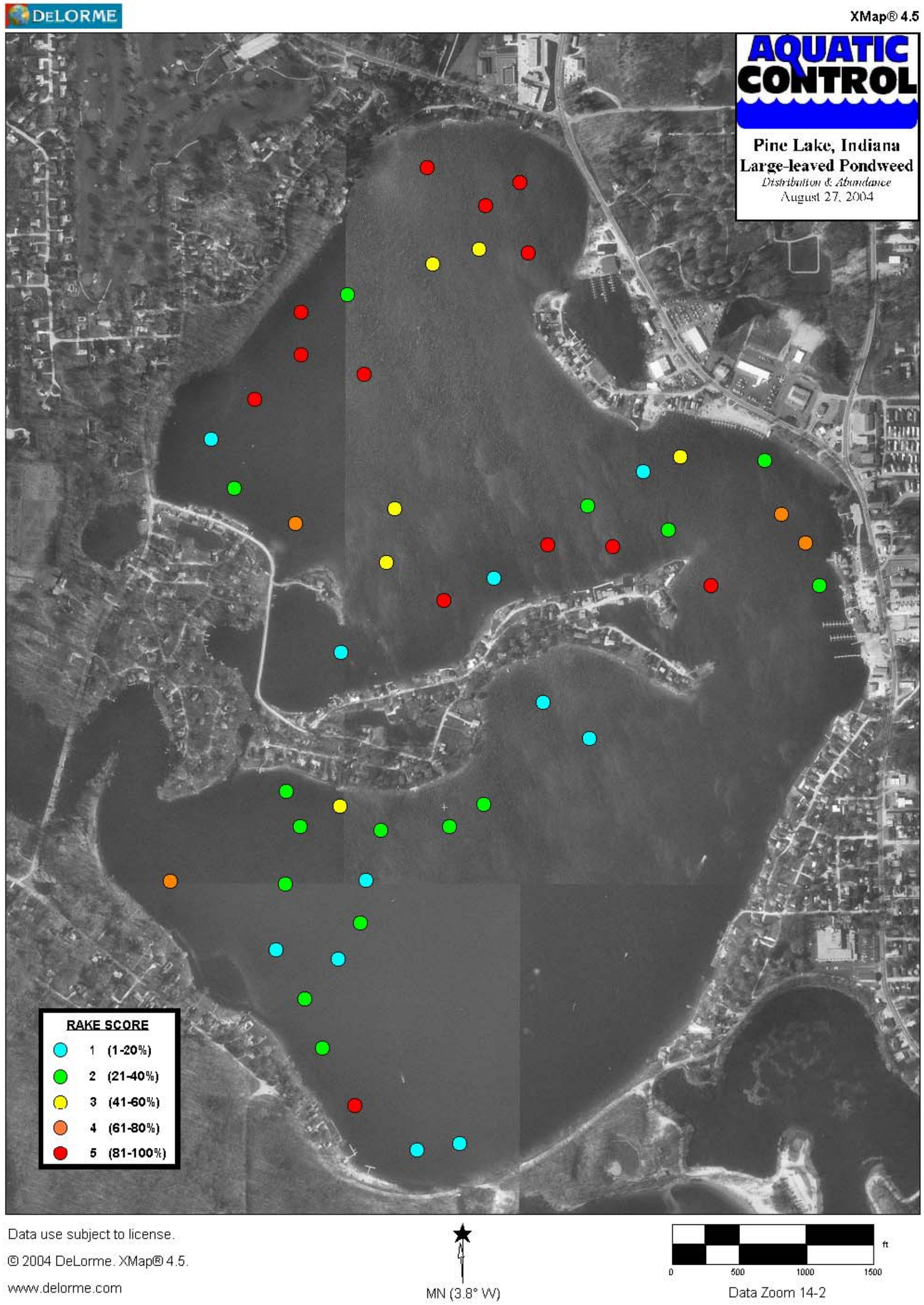
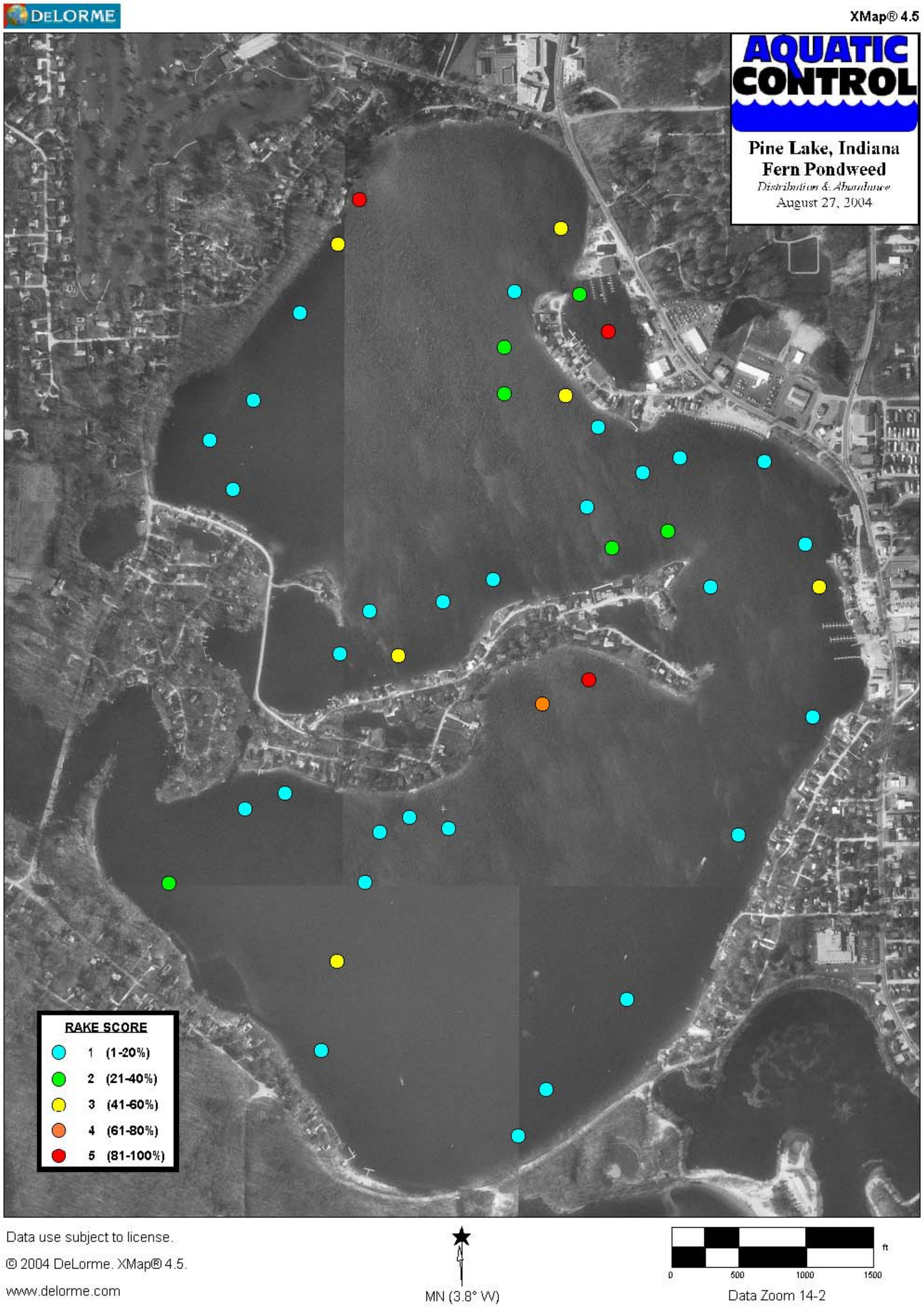
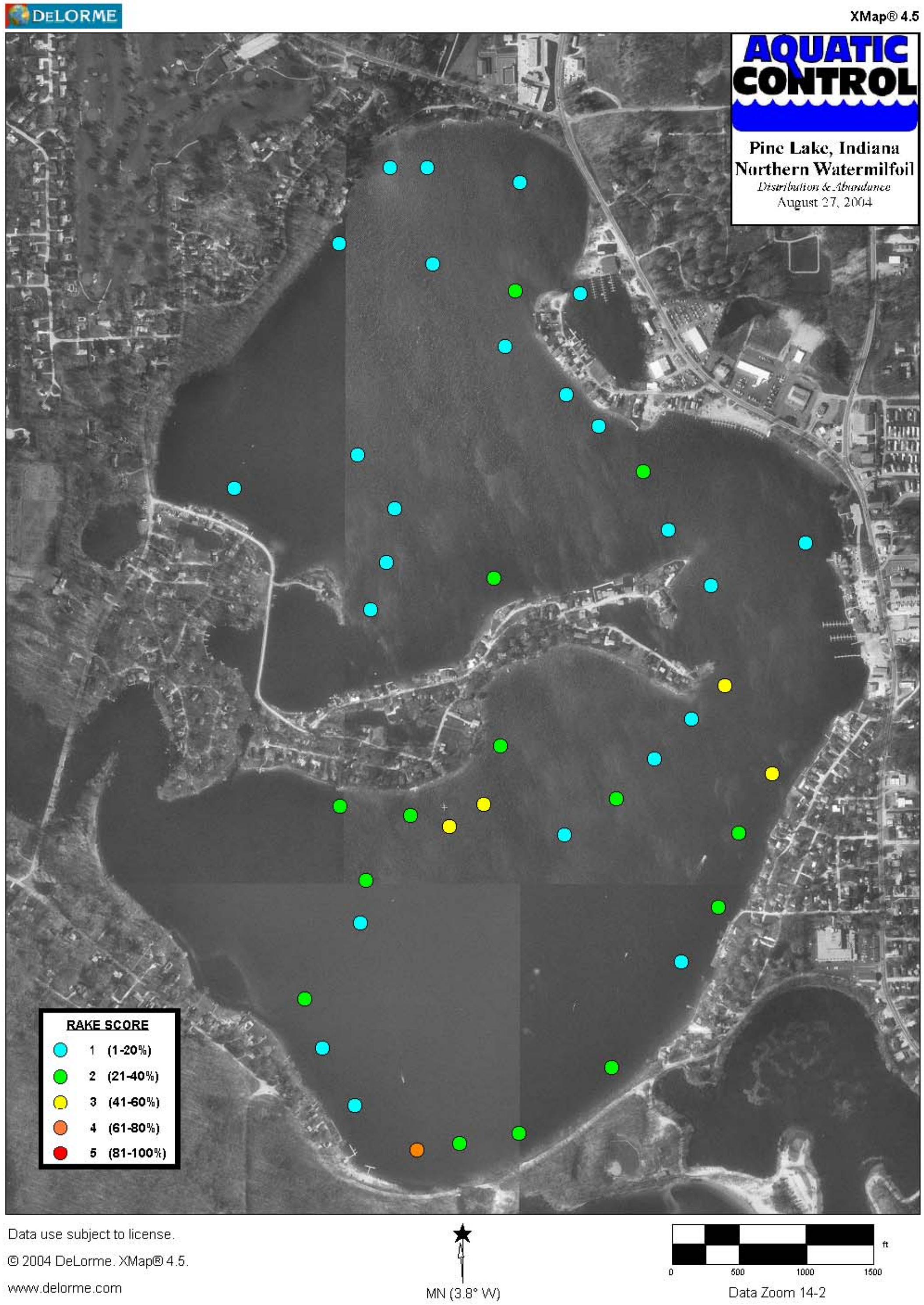
Data Zoom 14-2

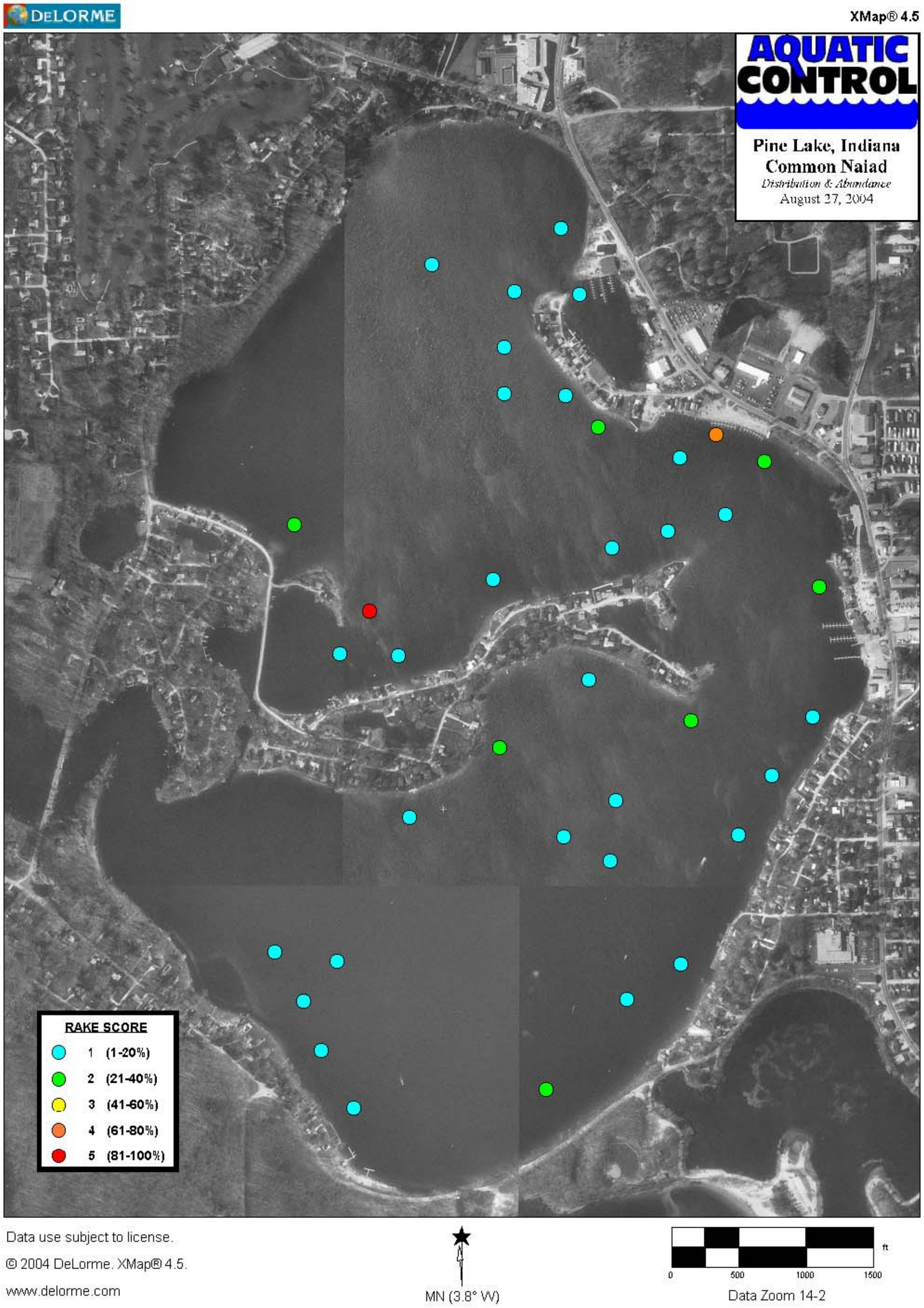

DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Aquatic Vegetation
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
0 500 1000 1500 ft
Data Zoom 14-2

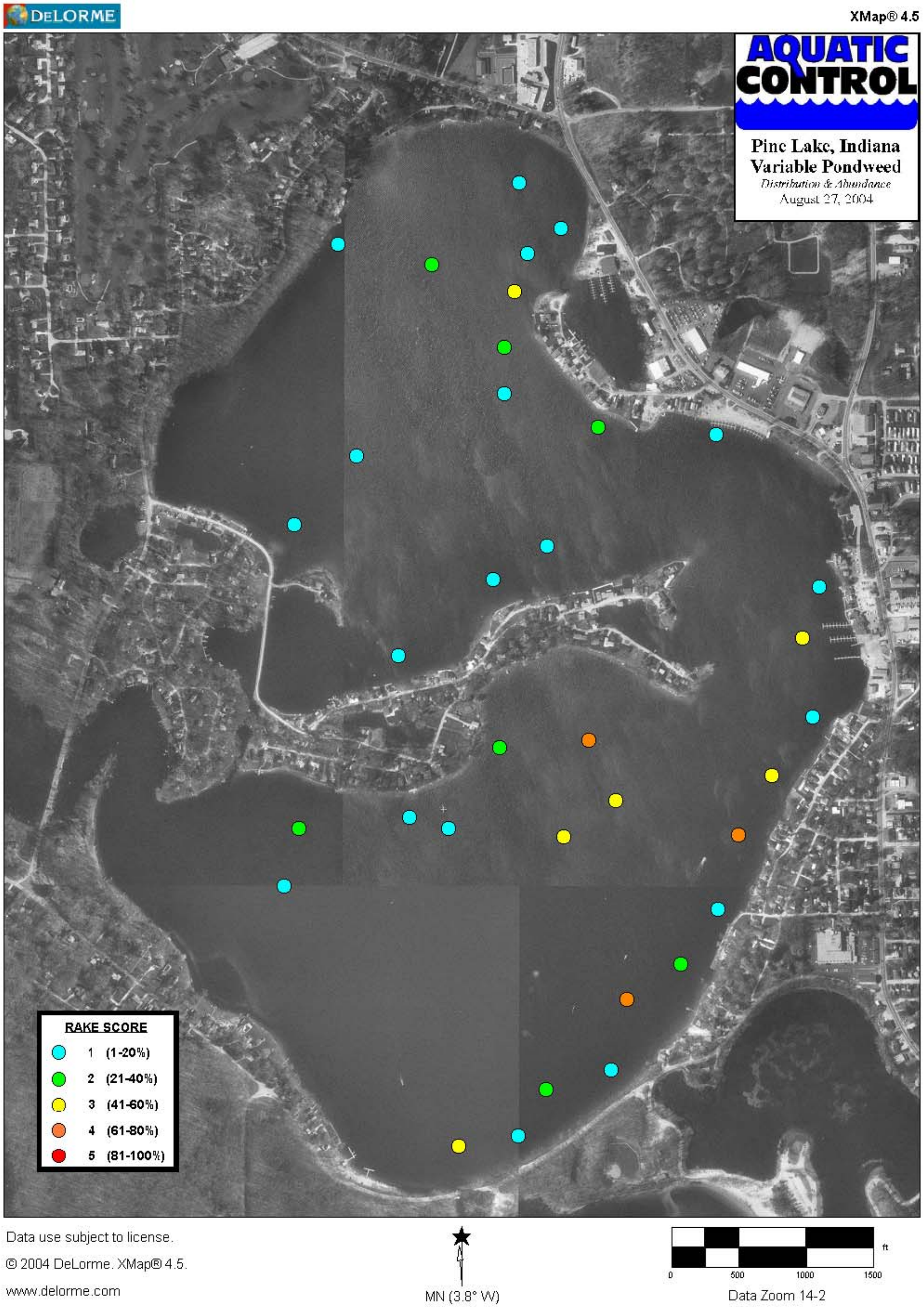

DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Eel Grass
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
0
500
1000
1500
ft
Data Zoom 14-2

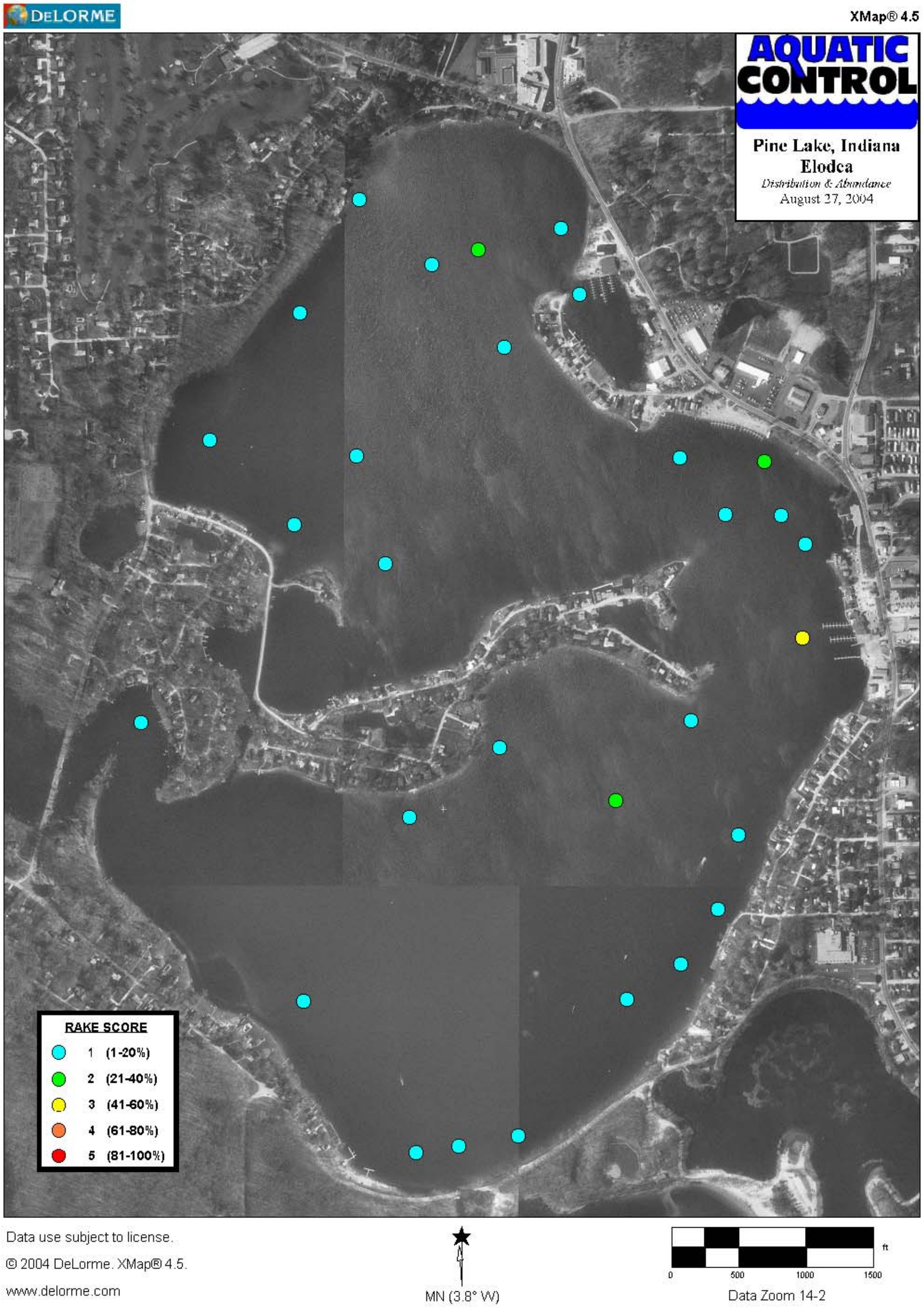

DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Large-leaved Pondweed
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
ft
0
500
1000
1500
Data Zoom 14-2

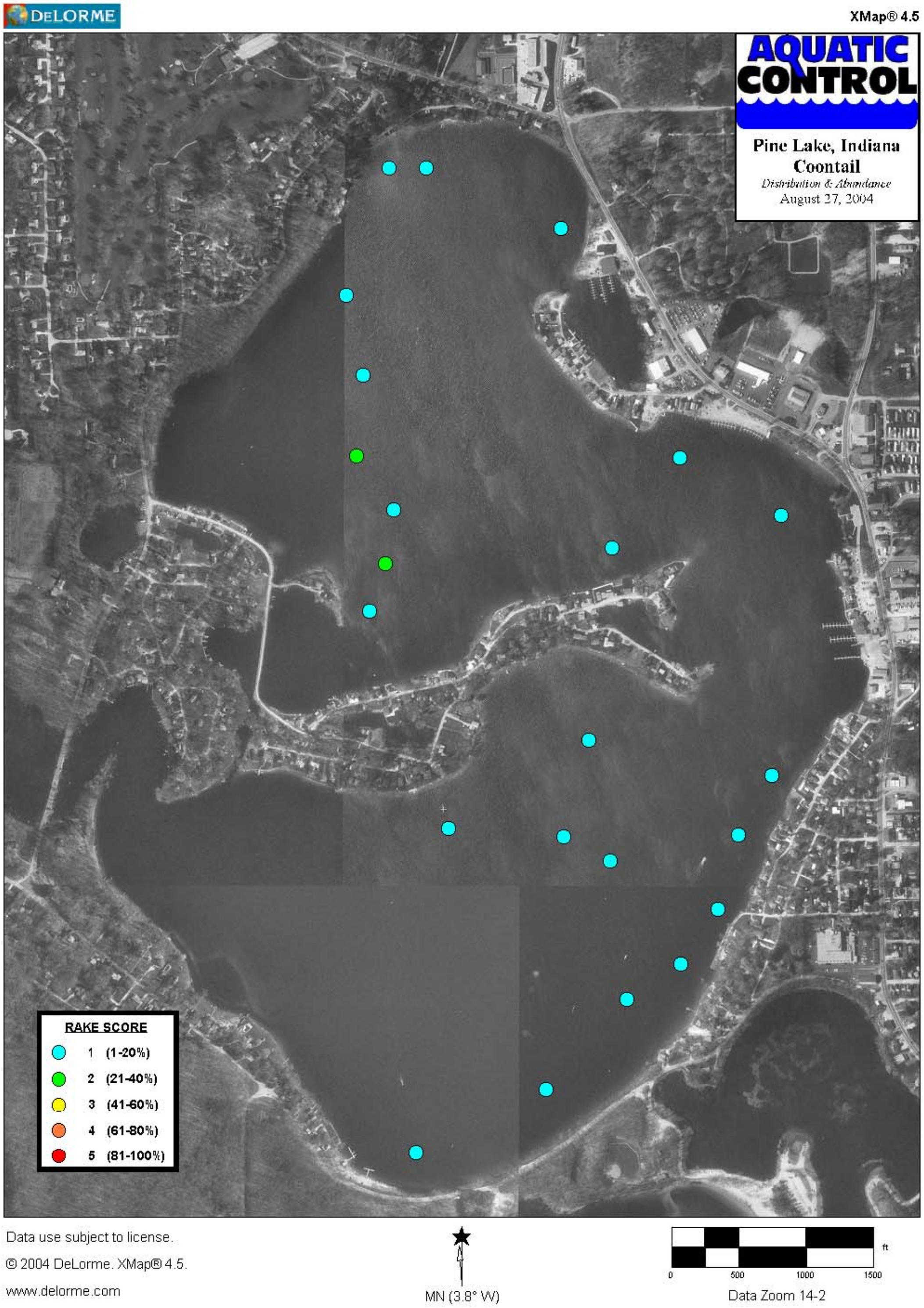

DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Fern Pondweed
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
0
500
1000
1500
ft
Data Zoom 14-2

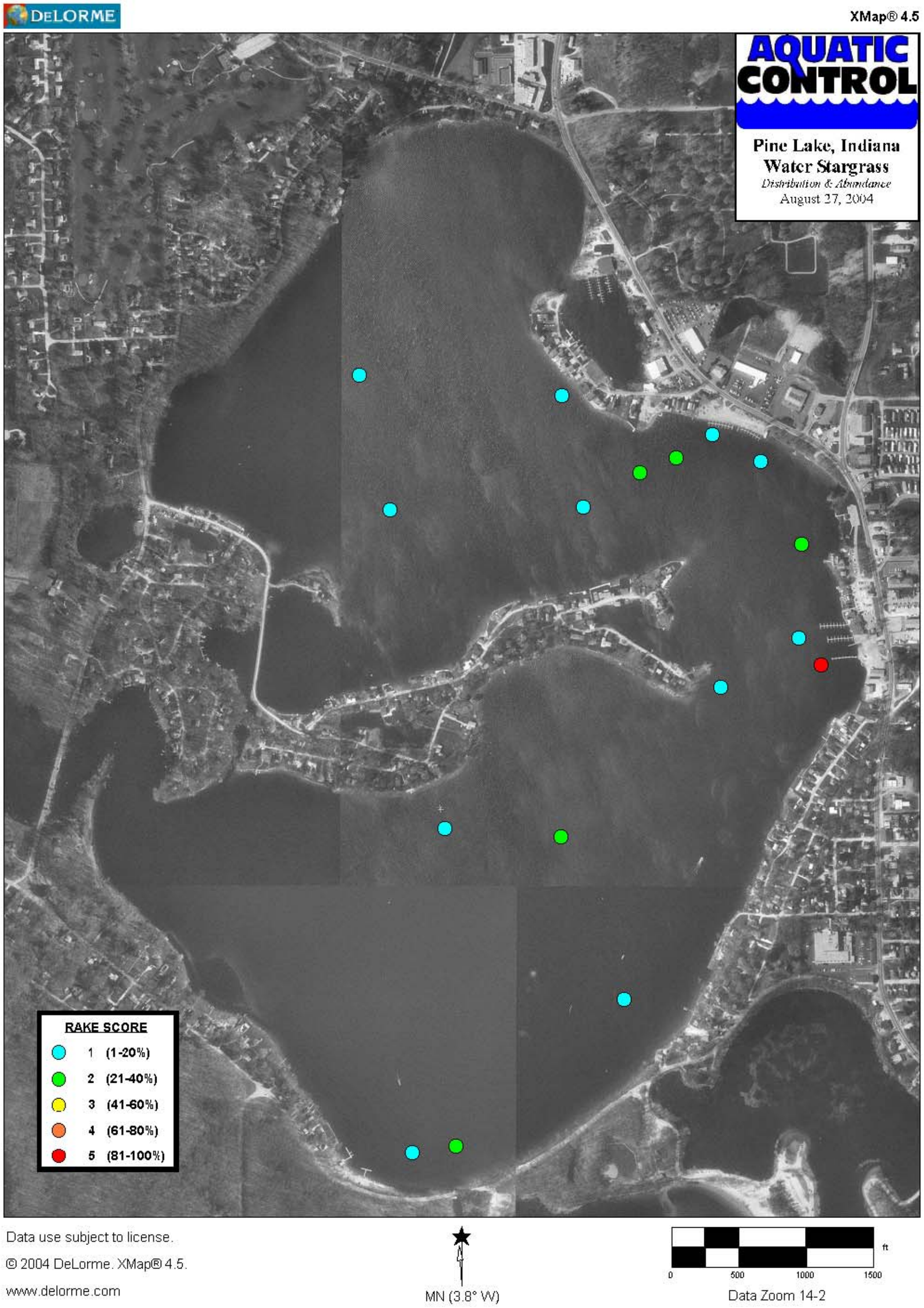

DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Northern Watermilfoil
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
0 500 1000 1500 ft
Data Zoom 14-2

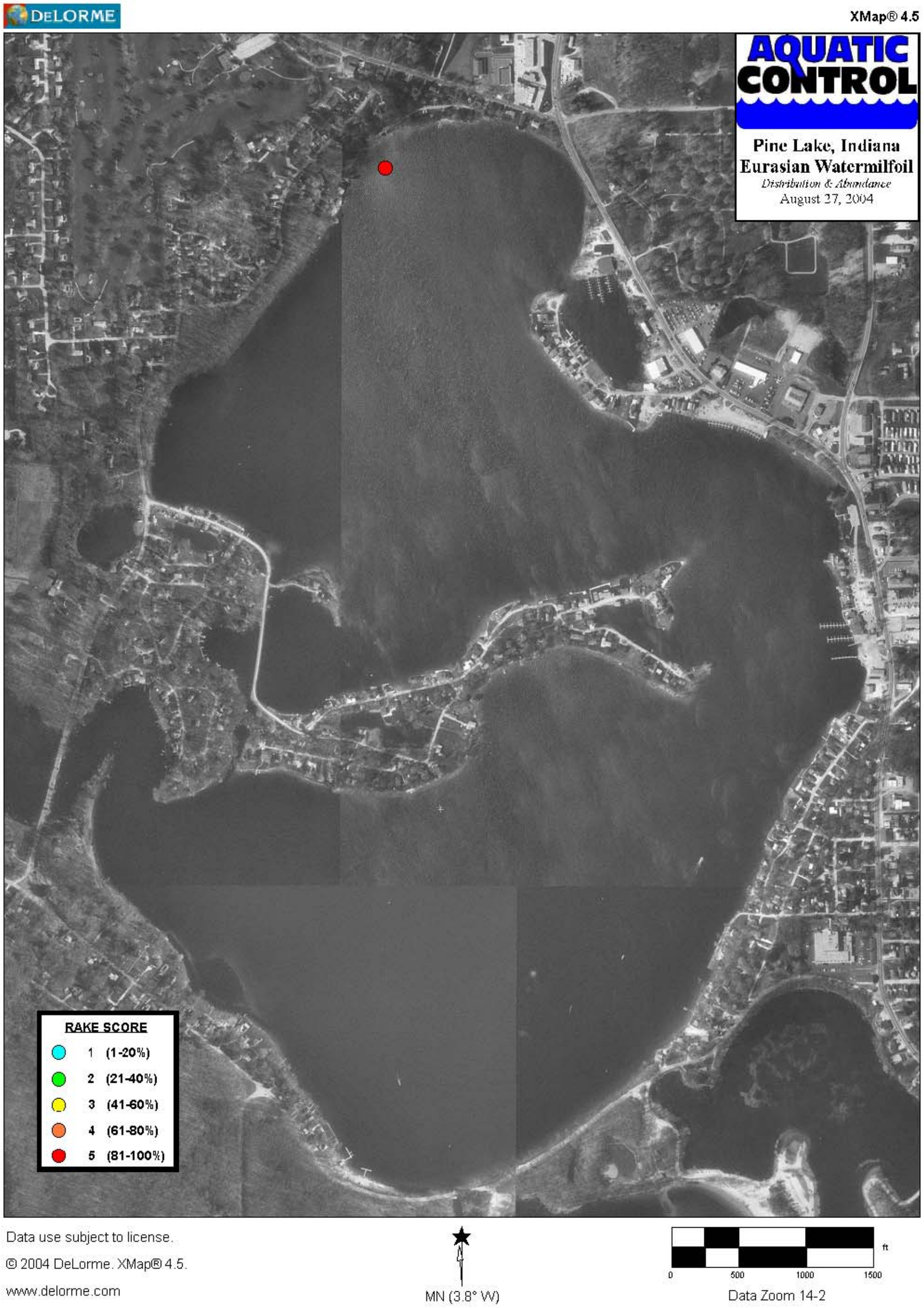

DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Common Naiad
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
0 500 1000 1500 ft
Data Zoom 14-2

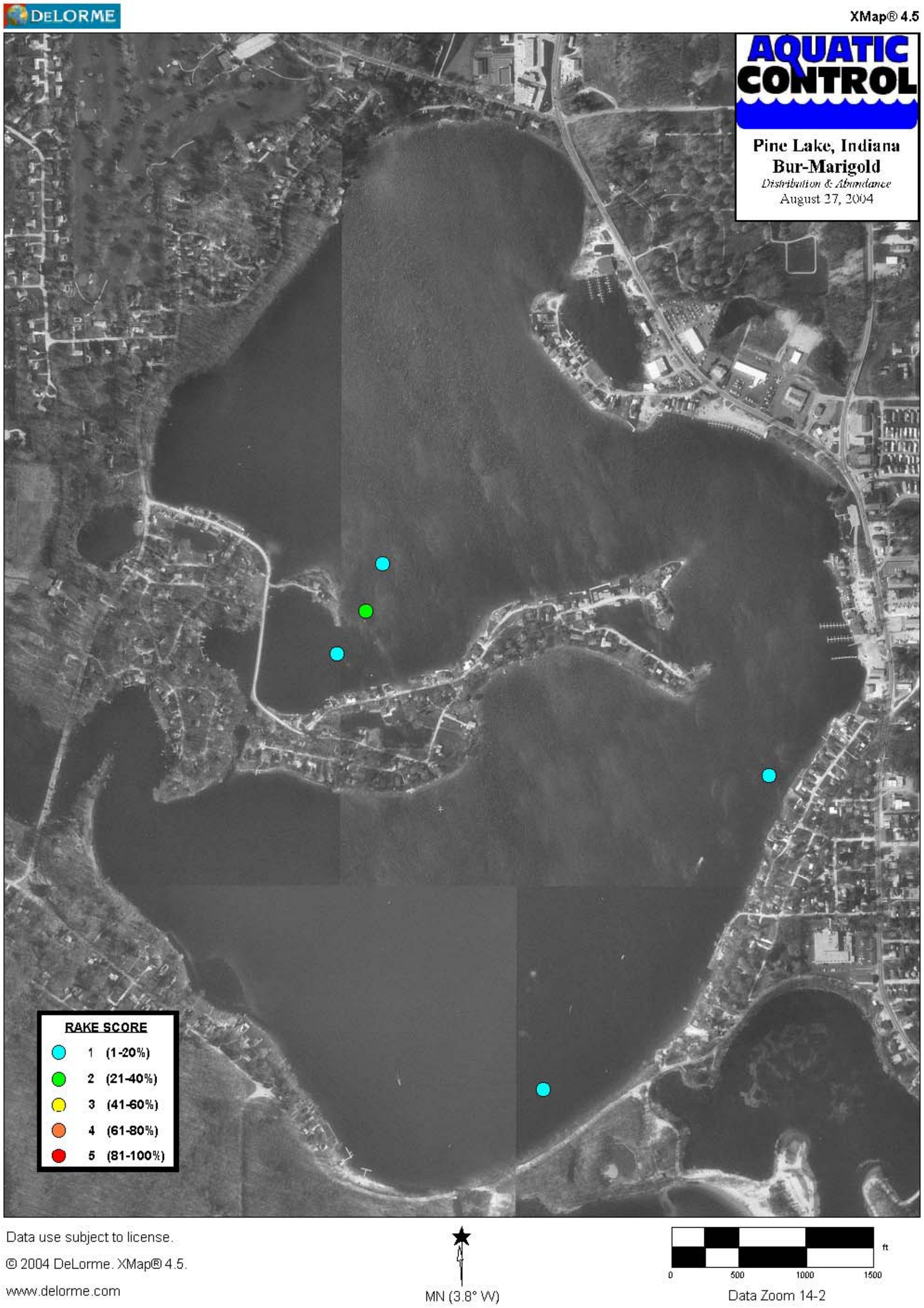

DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Variable Pondweed
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
ft
0
500
1000
1500
Data Zoom 14-2

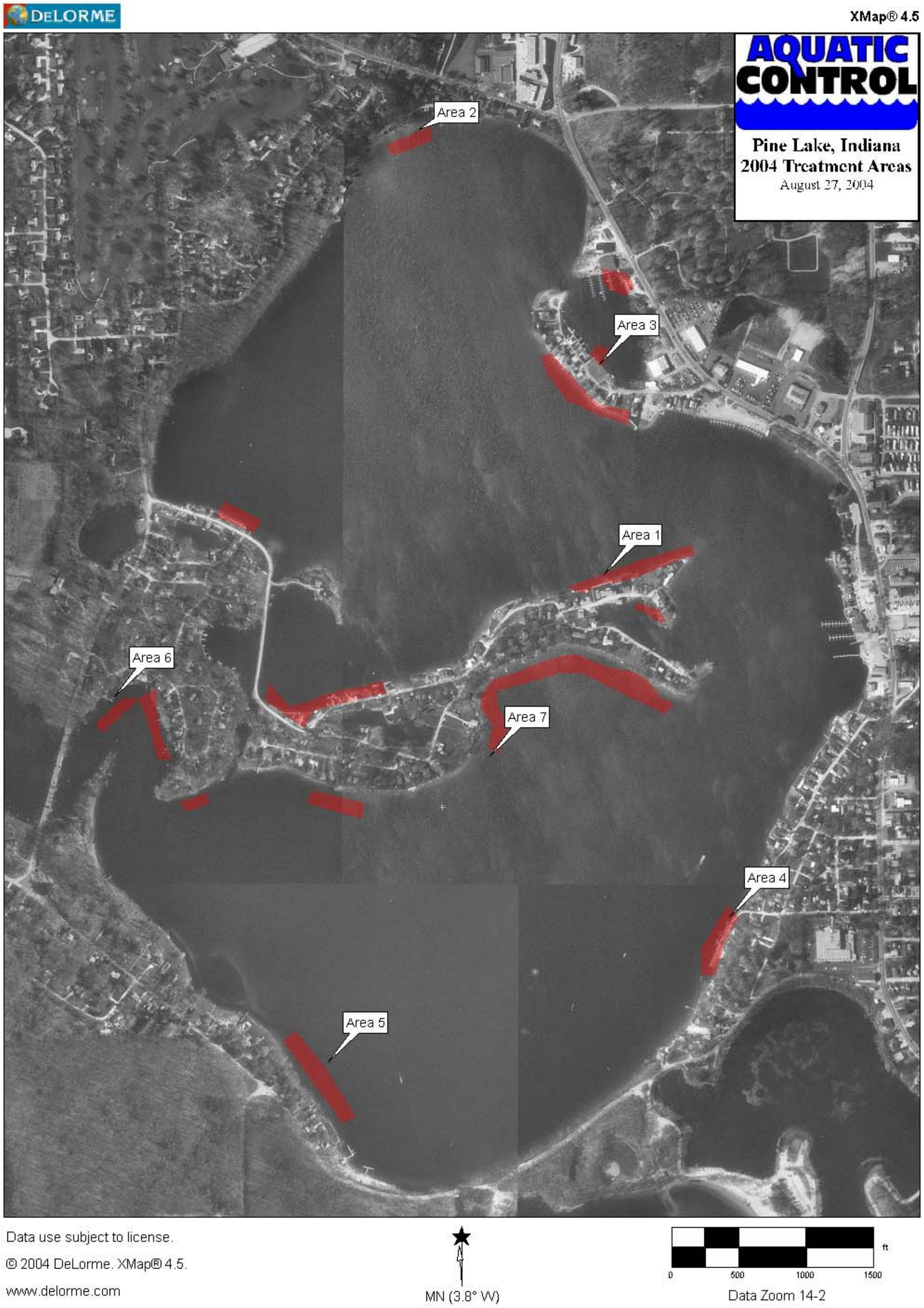

DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Elodea
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
0 500 1000 1500 ft
Data Zoom 14-2


DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Coontail
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
0
500
1000
1500
ft
Data Zoom 14-2


DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Water Stargrass
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
0 500 1000 1500 ft
Data Zoom 14-2


DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Eurasian Watermilfoil
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
0 500 1000 1500 ft
Data Zoom 14-2


DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
Bur-Marigold
Distribution & Abundance
August 27, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
0
500
1000
1500
ft
Data Zoom 14-2


DELORME
XMap® 4.5
AQUATIC CONTROL
Pine Lake, Indiana
2004 Treatment Areas
August 27, 2004
Area 1
Area 2
Area 3
Area 4
Area 5
Area 6
Area 7
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.8° W)
0
500
1000
1500
ft
Data Zoom 14-2

Appendix C. Tier II Sampling Data

Lake	Date	Latitude	Longitude	Site	Depth	RAKE	MYSP2	CEDE4	CH?AR	PORO	NAFL	POPE6	VAAM3	ELCA7	NAGU	POFO3	POZO	PORI2	POAM	POGR8	MYSI	MYHE	ZODU	BIBE	SpeNum
Pine	8/27/04	41.6295	-86.739791	224	8.0	5				3	2								2	1					4
Pine	8/27/04	41.63036	-86.740183	225	7.0	5				1			1	1					4		1		2		6
Pine	8/27/04	41.63094	-86.740832	226	9.0	5		1					1	1					4						4
Pine	8/27/04	41.63205	-86.741288	227	4.0	5				1	2		1	2					2				1		6
Pine	8/27/04	41.63259	-86.742607	228	3.0	5					4		2							1			1		4
Pine	8/27/04	41.63212	-86.743578	229	4.0	5		1		1	1			1					3				2		6
Pine	8/27/04	41.63182	-86.744582	230	6.0	5				1			2						1		2		2		5
Pine	8/27/04	41.63274	-86.745794	231	4.0	5				1	2									2	1				4
Pine	8/27/04	41.63337	-86.746679	232	4.0	5				3	1										1		1		4
Pine	8/27/04	41.63342	-86.748321	233	8.0	5				2	1		2							1					4
Pine	8/27/04	41.63436	-86.748342	234	5.0	5				2	1			1						2	1				5
Pine	8/27/04	41.63548	-86.748058	235	5.0	5				1	1		1							3	2				5
Pine	8/27/04	41.63633	-86.749034	236	8.0	5							1	2					3						3
Pine	8/27/04	41.63625	-86.747714	237	7.0	5							1						5	1					3
Pine	8/27/04	41.63543	-86.746287	238	4.0	4				2	1		2	1							1				5
Pine	8/27/04	41.63468	-86.745504	239	4.0	5				5															1
Pine	8/27/04	41.63675	-86.746797	240	5.0	5		1		3	1		2	1						1					6
Pine	8/27/04	41.63767	-86.74794	241	6.0	5													5	1	1				3
Pine	8/27/04	41.63721	-86.748873	242	8.0	5													5						1
Pine	8/27/04	41.63603	-86.750305	243	9.0	5					1			1					3	2	1				5
Pine	8/27/04	41.63799	-86.750434	244	7.0	5		1											5		1				3
Pine	8/27/04	41.63797	-86.751453	245	6.0	5	5	1													1				3
Pine	8/27/04	41.63735	-86.752247	246	8.0	5				5			1	1											3
Pine	8/27/04	41.63644	-86.752843	247	4.0	3				3										1	1				3
Pine	8/27/04	41.63541	-86.752617	248	16.0	3		1					1						2						3
Pine	8/27/04	41.63504	-86.753873	249	4.0	5				1			1	1					5						4
Pine	8/27/04	41.63419	-86.753873	250	6.0	5							1						5						2
Pine	8/27/04	41.63379	-86.752162	251	12.0	5		1											5				1		3
Pine	8/27/04	41.63328	-86.755133	252	4.0	5				1			2						5						3
Pine	8/27/04	41.63247	-86.756297	253	4.0	3				1			2	1					1						4
Pine	8/27/04	41.63147	-86.755675	254	4.0	3				1			1						2		1				4
Pine	8/27/04	41.63077	-86.754018	255	4.0	5					2		1	1					4	1					5
Pine	8/27/04	41.63216	-86.752333	256	4.0	4		2					1	1						1	1				5
Pine	8/27/04	41.63107	-86.751335	257	5.0	4		1											3		1		1		4
Pine	8/27/04	41.62997	-86.75155	258	4.0	5		2					1	1					3		1			1	5
Pine	8/27/04	41.62902	-86.75199	259	4.0	5		1		1	5		2								1			2	5
Pine	8/27/04	41.62814	-86.752784	260	3.0	2				1	1		1						1					1	4
Pine	8/27/04	41.62811	-86.751191	261	3.0	4				3	1		3							1					4
Pine	8/27/04	41.62919	-86.75	262	4.0	4				1									5						2
Pine	8/27/04	41.62965	-86.748637	263	4.0	4				1	1		1					1	1	1	2				7
Pine	8/27/04	41.63034	-86.747167	264	7.0	4							1						5	1					3
Pine	8/27/04	41.63112	-86.746094	265	5.0	2				1			1						2				1		4
Pine	8/27/04	41.63029	-86.745424	266	4.0	4		1		2	1		2				1		5						6
Pine	8/27/04	41.63063	-86.743895	267	4.0	4				2	1								2		1				4
Pine	8/27/04	41.63097	-86.742339	268	2.0	1			1		1			1											3
Pine	8/27/04	41.63015	-86.741722	269	20.0	0																			0
Pine	8/27/04	41.6295	-86.742752	270	5.0	5				1			2						5		1				4
Pine	8/27/04	41.62829	-86.74206	271	19.0	0																			0
Pine	8/27/04	41.62747	-86.742382	272	9.0	5							1				1				3		1		4
Pine	8/27/04	41.6268	-86.743283	273	10.0	5					2		3	1							1				4
Pine	8/27/04	41.62599	-86.744292	274	9.0	1							1								1	1			3
Pine	8/27/04	41.62518	-86.745311	275	12.0	5					1		1	2			1			3	2	1			7
Pine	8/27/04	41.62395	-86.745461	276	14.0	3		1			1		2			1						1			5
Pine	8/27/04	41.62445	-86.746711	277	11.0	5		1			1									3	1		2		5
Pine	8/27/04	41.6264	-86.746041	278	8.0	5		1					1						1	4					4
Pine	8/27/04	41.62762	-86.746035	279	6.0	5				5	1		1												3
Pine	8/27/04	41.62714	-86.747296	280	7.0	5				4									1			1			3
Pine	8/27/04	41.62625	-86.748471	281	4.0	5					2		1	1						2	2				5
Pine	8/27/04	41.62506	-86.748911	282	9.0	5							1				1	1	2		3				5
Pine	8/27/04	41.62462	-86.749844	283	8.0	5		1		1								1	2	1	3		1		7
Pine	8/27/04	41.62484	-86.750906	284	5.0	4				1	1		1	1						1	2				6
Pine	8/27/04	41.62453	-86.751716	285	5.0	4				1			2					1	2						4
Pine	8/27/04	41.62351	-86.752097	286	5.0	4				1			1						1		2				4
Pine	8/27/04	41.62266	-86.752263	287	5.0	4							1					1	2		1				4
Pine	8/27/04	41.62192	-86.75287	288	6.0	3				3	1							1	1						4
Pine	8/27/04	41.62111	-86.753755	289	4.0	5					1		1	1					2		2				5
Pine	8/27/04	41.6221	-86.754554	290	4.0	2					1	1	1						1						4
Pine	8/27/04	41.62345	-86.754302	291	5.0	3							1						2	1					3
Pine	8/27/04	41.62462	-86.753894	292	4.0	4							1						2	2					3
Pine	8/27/04	41.62503	-86.752805	293	4.0	5							1						3		2				3
Pine	8/27/04	41.62533	-86.75428	294	3.0	5				1			2						2						3
Pine	8/27/04	41.625	-86.755359	295	4.0	1				1															1
Pine	8/27/04	41.62425	-86.756474	296	4.0	2							1					2							2
Pine	8/27/04	41.62351	-86.757413	297	2.0	5				2		1							4						3
Pine	8/27/04	41.6246	-86.7578	298	3.0	0																			0
Pine	8/27/04	41.62568	-86.758009	299	3.0	1																1			1

Species Codes	
BIBE	Bur marigold
CEDE4	Coontail
CH?AR	Chara
ELCA7	Elodea
LEMN	Duckweeds
MYHE	Broadleaf watermilfoil
MYSI	Northern watermilfoil
MYSP2	Eurasian watermilfoil
MYVE	Whorled watermilfoil
NAFL	Slender naiad
NAGU	Southern waternymph
NAMA	Spiny naiad
NAMI	Brittle waternymph
NELU	American lotus
NI?TE	Nitella
NOAQVG	No aquatic vegetation
NULU	Yellow pond lily
NYTU	White water lily
POAM	Large-leaf pondweed
POCR3	Curly-leaf pondweed
POFO3	Leafy pondweed
POGR8	Variable pondweed
POIL	Illinois pondweed
PONO2	American pondweed
POPE6	Sago pondweed
POPR5	White-stemmed pond
POPU7	Small pondweed
PORI2	Richardson's pondwe
POZO	Flat-stemmed pondw
UTMA	Common bladderwort
VAAM3	Wild celery, eel grass
WO?LF	Watermeal
ZAPA	Horned pondweed
ZODU	Water stargrass
Count	34

Lake	Date	Latitude	Longitude	Site	Depth	RAKE	MYSP2	CEDE4	CH?AR	PORO	NAFL	POPE6	VAAM3	ELCA7	NAGU	POFO3	POZO	PORI2	POAM	POGR8	MYSI	MYHE	ZODU	BIBE	SpeNum	Species Codes
Pine	8/27/04	41.62676	-86.75817	300	3.0	2								1								2			2	
Pine	8/27/04	41.62012	-86.753299	301	4.0	4				1	1	1	1						2		1				6	
Pine	8/27/04	41.61895	-86.752408	302	5.0	5					1		1						5		1				4	
Pine	8/27/04	41.61974	-86.751346	303	10.0	0																			0	
Pine	8/27/04	41.61805	-86.750729	304	9.0	5		1					1	1					1		4		1		6	
Pine	8/27/04	41.61817	-86.749565	305	7.0	5							3	1					1	3	2		2		6	
Pine	8/27/04	41.61838	-86.747967	306	5.0	5				1			3	1						1	2				5	
Pine	8/27/04	41.61933	-86.747194	307	12.0	3		1		1	2		1							2		1		1	6	
Pine	8/27/04	41.61973	-86.745451	308	3.0	4							1							1	2				3	
Pine	8/27/04	41.62115	-86.745011	309	10.0	5		1		1	1		2	1						4			1		7	
Pine	8/27/04	41.62187	-86.743541	310	7.0	4		1			1		1	1						2	1				6	
Pine	8/27/04	41.62298	-86.742554	311	5.0	5		1						1			1			1	2				5	
Pine	8/27/04	41.62448	-86.742001	312	13.0	5		1		1	1			1	1					4	2				7	
Pine	8/27/04	41.62569	-86.741079	313	6.0	5		1			1		1							3	3			1	5	
Pine	8/27/04	41.62687	-86.739968	314	5.0	1				1	1									1					3	
Pine	8/27/04	41.62792	-86.739657	315	5.0	5																	5		1	
Pine	8/27/04	41.62847	-86.740263	316	8.0	5								3						3			1		3	